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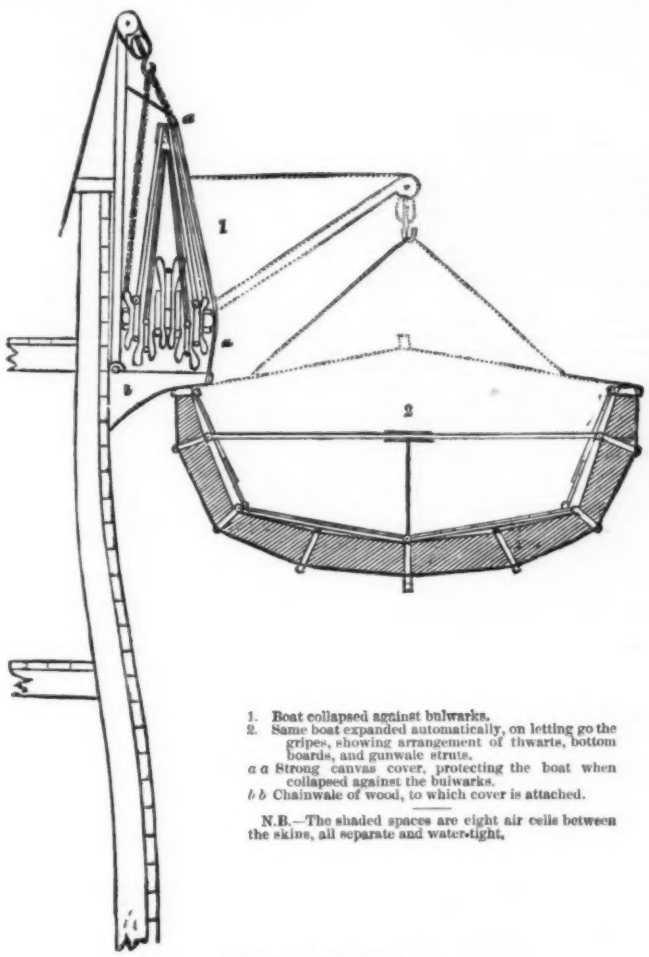
COLLAPSIBLE BOATS.

By Rev. E. L. Berthon, M.A.*

It will be quite unnecessary, in these days, to impress upon the members of the Society of Arts the urgent demand for increased and improved means of saving life at sea, and therefore I need not begin, as many inventors do, by making out a case to show that there is a real want which they propose to meet.

It is not denied that considerable progress has been made in the life-boats carried by ships. No one can inspect the magnificent troop-ships which at this moment are engaged in carrying our soldiers to and from our Indian Empire, or the splendid steamers of the Peninsular and Oriental Company, and the many still larger ships of other companies that convey passengers to all parts of the world, without being struck by their greatly improved boat accommodation; nevertheless, it is equally manifest that, when all that is possible has been done with existing appliances, there is still a lamentable deficiency; for when carrying their full amount of troops or passengers, not one such ship has ever put to sea with boats of any kind capable of saving one-half of the people on board, in the awful event of fire, wreck, or collision. For instance, let us take the most favorable case in existence. It is not uncommon for one of H.M. Indian troop-ships to convey at one time 1,700 men, women, and children; every available spot in which a boat can be stowed is utilised, so that each of these ships carries fourteen boats, four of them being the largest troop-boats in the service; yet were a fatal accident to befall such a ship—which God forbid—and, by some grand display of discipline and self-denial, all those boats were safely launched, and filled with people, only 600 at the utmost could be saved, and 1,100 must inevitably perish.

In emigrant ships the deficiency reaches its most appalling limit. The regulations of the Board of Trade with respect to boats have no regard whatever to the number of persons a ship may carry, but only to the size and tonnage, and thus it came to pass that, in two typical cases of frightful loss of life by collision and fire—the Northfleet and the Cospatrick—the official report of the Board of Trade inquiry, after stating the number and capacities of the boats, and thus showing that they would not have held one-third of the human beings, makes this startling announcement, almost in the same words in each case, that "the ship was well supplied with boats, which were in excess of what is required by law!" I submit the fact that such a state of things should be tolerated is a reproach to the intelligence and humanity of the age.



1. Boat collapsed against bulwarks.
2. Same boat expanded automatically, on letting go the gripes, showing arrangement of thwarts, bottom boards, and gunwale struts.

a a Strong canvas cover, protecting the boat when collapsed against the bulwarks.
b b Chainwale of wood, to which cover is attached.

N.B.—The shaded spaces are eight air cells between the skins, all separate and water-tight.

Fig. 1.—MIDSHIP SECTION.

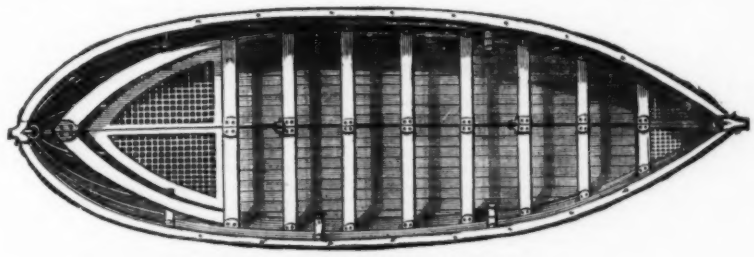


Fig. 2.—GUNWALE PLAN OF THE BOAT.

But it is not only the deficiency of boat accommodation that so frequently causes such fearful sacrifice of life. There is another fatal evil which is very common, even in those cases in which the number of persons happens to be small, I mean the practice rendered necessary of carrying the boats inboard, or on the booms, or often bottom upwards, so that, though the boats might be sufficient if they could be got into the water, they cannot be lowered in time; such was the case with the Strathmore, and probably the Strathclyde too.

Again, it is more strongly urged that the most frequent spectacle of a mad and selfish spirit of self-preservation—too frequent in cases where many human beings are included in a common danger, and panic-struck individuals communicate their frenzy to the rest—is a fatal obstacle to all efforts to save life. This objection requires a fuller reply. Admitting that this selfish spirit of "*sauve qui peut*" is generally exhibited, and that hitherto it has acted as the insuperable hindrance to the proper use of the boats of a ship in time of extreme peril, there is no reason why this state of things should continue. I hold the opinion strongly, and I am able to prove it by very many instances, that the panic, hitherto so fatal, need not and would not ensue, if proper and abundant means of safety were not only in existence, but known to be at hand. Imagine two cases of ships that must sink within, say an hour, both crowded with passengers and crew. In the one case the captain knows but too well that, at the best, three out of every four must perish; how can he expect to calm the frantic and cheer the despondent? They know, as well as he does, that his boats will not hold a quarter of them; nor can he prevent that fatal rush by which, more frequently than not, the boats are improperly lowered, and those that crowded into them on the davits are lost.

In the other case, in which it is well known to all that there is abundant means of refuge to every soul on board, how different the state of things. The master of such a ship has hopeful grounds for calling all to their duty, and to maintain discipline and order. With cheering voice, though he tells them that the fate of the ship is sealed, yet in all probability, he says, she will float another hour, and if they will only obey orders, and not crowd into the boats, they will all be saved. In the terrible fire on board the Cospatrick some two years ago, we have a case that sadly illustrates this point. That ship, when she took fire, had about 480 people on board, and her boats, as shown by the report of the Board of Trade, would not have carried with safety more than about 150. In an early stage of the conflagration it is stated that Mr. McDonald, the chief officer, asked Captain Elmslie, who commanded the ship, the following question: "Shall I put out the boats, sir?" "No," said the Captain, "put out the fire." For this his memory has been charged with want of judgment, and it is said had he ordered out the boats at that moment more lives might have been saved. I do not think so. All told, the crew and officers numbered only 44, the rest were the most helpless class of landsmen, who were rushing about the deck, far beyond control. Let us suppose it possible to have launched those boats (most of them stowed inboard) at all, it would have taken the whole ship's company to do it, and what is more, the moment the boats touched the water it would have been necessary to pull away at once; to lay one minute alongside would have been fatal, for the men and women jumping into them would certainly have swamped them.

But, happily, history records cases of heroic self-denial, and the preservation of perfect discipline in the most appalling scenes of wreck, *e. g.*, the troop-ship Birkenhead, wrecked some 25 years ago in Simon's Bay. There the brave soldiers, after handing the women and children into the few boats they had, stood in their ranks on deck as steady as if on parade, and even fired their own funeral volley when the ship's deck sank below the waters. Can any one doubt that if they had been supplied with efficient and abundant boats they would all have been saved?

Or to recur to another case, the Northfleet; if she had had her boats, not only sufficient in quantity, but properly stowed ready for use in a moment, instead of having them turned bottom upwards on the skids, would not a far larger number of her helpless passengers have been saved?

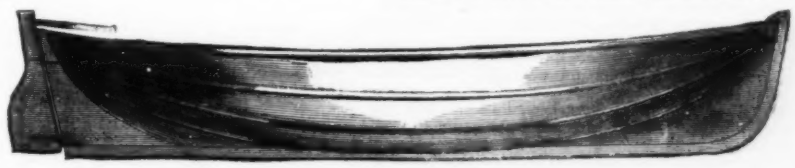


Fig. 3.—PROFILE OF THE BOAT.

It has been said that no increase of boat accommodation could avail to save all the lives in case of some supreme disaster. In reply, I admit that there are cases of such an awfully sudden nature as to give no time for the employment of the most ready and perfect appliances; but the accounts we have had of the most terrible catastrophes at sea in the last thirty years are enough to show that, in a very large majority of cases, there was ample time to launch the boats, had they been ready for service.

The two things absolutely necessary to make any system perfect are, first, that the boats should be abundant and efficient; and second, that they should be stowed so as to be available at any moment, without the labor and loss of time expended in hoisting them out. Both these desiderata are secured by the system of collapsing boats, which I now

* Read before the Society of Arts, London.

have the honor of presenting to the Society of Arts, for not only can boats of this kind be carried in number and capacity very far exceeding those hitherto in use, but, owing to their great reduction in size when shut, they can be carried outboard without the slightest risk of injury; in fact, they collapse into about one sixth of their width.

Perhaps I may be pardoned if I here relate the personal circumstance which first brought the idea of such boats to my mind. It may be in the recollection of some present that, on a calm and lovely summer night in June, 1849, one of the most melancholy shipwrecks on record occurred. The Orion was a favorite iron steamship, employed in carrying passengers between Liverpool and Glasgow. On her last and sadly fatal trip she had a large number of passengers, nearly all of the first class, bound for tours in the Highlands, and if ever freedom from danger could be justly premised at sea, it was so then. They had reached a part of the coast close to Portpatrick, without a cloud in the sky or a ripple on the water, when, just as the first streak of dawn was appearing in the northeast, by the most extraordinary carelessness, the ship was run on a sunken rock, close to the lighthouse, and not two cables length from the shore. After hanging a few minutes on the rock, she slid off, and sank in deep water, carrying with her 200 persons, of whom 150 were drowned. Of her boats, three or four in number, owing to the rush that was made to them, only one was successfully launched, and that was taken by the sailors and firemen, who left the passengers to perish.

A clerical friend of mine, who was saved in a wonderful manner, though he was no swimmer, writing a narrative of the wreck, and knowing that I was a good draftsman and acquainted with this particular ship, begged me to make a drawing of the final plunge, to illustrate his little book, and it was while preparing it for the engraver that I suddenly conceived the principle of collapsing boats.

I will not weary the members of this Society with a recital of the mountains of difficulties that, for more than a quarter of a century, have stood in my way; but this I must say, they chiefly were not of a mechanical or structural kind, but personal. I had to fight the battle singlehanded, and nothing but faith and confidence in the invention which a Higher Power had put into my mind, and a sense of certainty that some day it would prevail, carried me through. And now I am thankful to say that these boats are to be found in all parts of the world. They have been adopted by the Admiralty and the India Board, and though hitherto shipowners stand off as being free from all responsibility with regard to the lives of their crews and passengers, so long as they act up to a most defective law, I may confidently assert that the day is not distant when this system of supplementary boats will be general. I have just received a most gratifying letter from a gentleman of great influence in the mercantile marine, who is personally interested to a large extent in steamships in the East, and he wishes to be the first to apply these boats to ships carrying large numbers of passengers.

It is not easy to describe the details of these boats, as the whole structure, from first to last, differs entirely from all others. But, probably, the following will give some idea. Imagine a long melon cut into thin slices, their shape will be more or less lenticular. Now, suppose these to be jointed together at each end, so as to lay flat side by side, like the leaves of a shut book, or to take any other positions radiating from a central line. Now, if when a certain number of such segments, properly placed at certain distances, are connected together by some flexible material on their outer edges, and made water-tight, the structure becomes a boat; but, having as yet only one skin, it would only float so long as that skin is not pierced. But now let us suppose another skin to be applied to the inner edges of these lenticular segments, and made water-tight, not merely is there then a boat within a boat, but the spaces between the segments being all separate and distinct, an injury to one does not affect the rest.

In practice these flat segmental timbers are made by bending, with the aid of steam, slips of hard, elastic wood (preferably, Canada elm), one over the other, in a mould of the proper form, till the proper width is attained, and then clinching them together with copper rivets.

The frame-work is chiefly of wood, of the strongest and most elastic kind. To the keelson, or backbone of the boat, the stem and stern posts are attached, and on each side are four longitudinal curved timbers, which are jointed to the tops of the former by a peculiar kind of chain-hinge. When shut, these timbers fall down on each side of the keelson in vertical and parallel planes; and when open they assume such positions as to form the skeleton of a boat, extending two skins (one outside, the other inside) of a very strong and highly flexible material. The whole body of the boat is thus divided into eight segmental compartments, into which air is inhaled automatically, by the act of expansion. These cells being all separate and watertight, any injury that might befal one of them does not affect the others, nor materially impair the safety of the boat.

HORSE AND ARTILLERY BOATS.

By order of the Admiralty, I have built collapsers 40 ft. by 18 ft. 6 in., which have, on repeated trials, performed their duty in a most perfect manner. Such a boat carries eight horses and the heaviest field gun with the gunners and her crew. To embark or disembark these on a beach, one of the gunwales is lowered down nearly to a level with the deck, when the horses walk in or out, and the gun follows. These boats, the largest of any in the service weigh only 2 tons 15 cwt., and shut into 2 feet 6 inches.

PLEASURE BOATS.

Hundreds of these collapsers of small size are now in use in all climates for fishing, shooting, and other purposes.

As yachts' lifeboats they are very convenient, and as dingies and punts they are greatly in demand, although for lack of capital they are not advertised.

Twin boats on this principle are now navigating the lakes of Central Africa, and are found extremely useful for a variety of purposes.

Several collapsing canoes have been built of full size, which shut into three inches; they are quite equal in speed to the Rob Roy.

A kind of catamaran has just been built on this principle; it is the stiffest and by far the fastest thing afloat in the world.

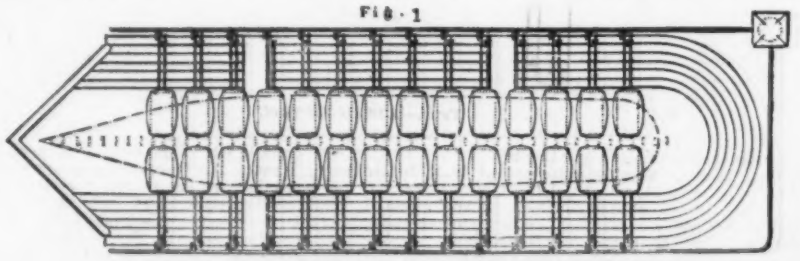
These are a few out of a great number of secondary applications of the collapsing principle, and are of minor importance. I rejoice in this opportunity of bringing the far more important bearing of it before the members of the Society of Arts, feeling confident that their intelligence and influence will go far to apply whatever is good in it to the all-important end of saving life at sea.

Mr. Berthon further said, though an inventor and a clergyman, he had some practical knowledge of the subject, having spent much time at sea at different periods on board men-of-war. He would not do away with boom boats, but he objected to making them the only stand-by, and to their being filled with sheep and pigs, and all sorts of lumber. He had used India-rubber years ago, and it proved one of his greatest enemies. He procured some of the very best quality, which stood a heat of 400°, and the most intense cold, and when stretched it kept all right, but, unfortunately, when folded up and sent to a hot climate, it contracted so that the boats could not be opened without stamping on the thwarts and breaking them, and this caused the Admiralty to reject his invention years ago, for they would not allow him to try anything else. He now used several thicknesses of canvas, No. 0, or 00, saturated with a composition of ground yellow litharge and boiled oil, and in every ten pounds was dissolved 1 lb. of yellow soap. This kept it soft and pliable, and increased its strength. He had some which had been exposed to the weather for four years, and was as good as ever. The word coracle no doubt came from *coriaculum*, a little leather structure, and this name was given to the ancient British boats by the Romans; but the coracle only had one skin, and did not collapse. With regard to the objections that the boats were liable to injury, and should be made in water-tight compartments, he already mentioned that they were all so made, and this construction gave them great power of flotation, so that, even if filled with water, they would carry as many persons as they were intended to. With regard to the strength of the structure, the timbers were not cut out of a solid piece, but were bent and spliced together, so as to combine the greatest strength and elasticity. On one occasion, when taking a boat 17 ft. wide down to Messrs. Siemens' ship Faraday, when lying alongside a wharf, she was run into by a smack coming down the river, and her side bulged in at least a foot; but as the smack went back, so the bulge came out, and the boat was none the worse. The same boat went out, and laid the shore end of the Atlantic cable on the American shore, which weighed one cwt. to the yard, but, unfortunately, she was left on the beach all night with ten tons of cable in her, and got knocked to pieces there by a strong gale of wind. As to the danger of the boats being washed away, theory was one thing, and sanguine hopes were another, but facts were the true test. When the Perseverance first took these boats to sea they were slung in the waist; she was very deep, and before she got to Ushant she fell in with a tremendous gale of wind, which carried away both the quarter cutters, but the collapsible boats were not injured to the extent of a halfpenny. A boat might be carried away in two ways—by a sea striking her under, lifting her up, and allowing her to dash down again, or by a heavy sea falling upon her; but these boats which were close up to the bulwarks, and securely lashed with strong gripes, could not be affected in either of these ways. In the Assistance the boats are carried just abaft the catheads, in the most exposed parts of the ship, and are often pitched clean under the water, but she carried them more than twelve months, through many a gale of wind, and they never received the slightest injury. He had sometimes been asked how he would do if one got on the rocks? His reply was, that a boat ought not to get on the rocks, and if she did it was time to get out of her. Having shown by the model how the canvas was attached, he explained that in case any damage occurred it was easy to put in another piece, or a patch of canvas could be put on with a thick solution of shellac; or if the rent were large, the edges might be caught together, and then a piece be put over it. On one occasion, when bringing a boat 32 ft. long from Sheerness to Spithead, when it was being hoisted up from the deck one of the blocks gave way, and the boat fell down 9 feet on to a 68-pounder, which went clean through the bottom segment. However, he went ashore in her all right, which he could not have done in a wooden boat. With regard to putting men on board before launching, he had no objection to it, but it increased the difficulty and danger of lowering. It was not always in a gale of wind or in very bad weather, when you could not get under a ship's stern, that accidents occurred; a fire or a collision might occur in calm weather, and sometimes a ship got on a rock in a fog. But in many cases he believed it would be far better to follow the rule in the navy, where the boats were lowered with only the crew in. On the whole, if there were more dangers of some kind with these boats, they enjoyed some immunities which others did not. The frame work was quite strong enough to bear the weight of a boat load when suspended, which would be seen from the fact that the small model on the table, only 6 ft. 4 in., when placed on two chairs, had supported the weight of a man.

CLARK AND STANDFIELD'S AIR CUSHIONS FOR DOCKS.

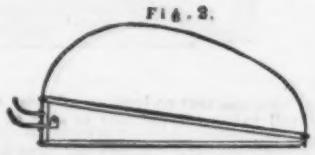
Some time since, Messrs. Clark and Standfield, of Westminster, designed a ship float, in which one of the special features was the introduction of air bags which, when distended, served to support the vessel within the dock or float. The annexed engraving shows the application of similar

Fig. 1



CLARK AND STANDFIELD'S AIR CUSHIONS FOR DOCKS.

Fig. 2.



cushions to ordinary graving docks. The cushions are composed of layers of canvas and rubber, capable of resisting a strain of about 40 lb. to the inch, and they are inflated by means of air compressors worked by engines at the side of the dock. They are protected outside with rope matting. Fig. 2 shows the form of the bag when inflated, as well as the inlet and relief pipes, the latter employed to allow the air to escape after a given pressure has been exceeded. Access to any part of the ship's bottom can be gained by allowing the air to escape from one or more bags, and so making it clear of the ship, while the latter is supported by adjacent cushions.—*Engineering.*

SCIENCE AND WAR.

Recent wars have had particular interest for the man of science. If we go back some fifteen or twenty years and consider the different wars which have unfortunately occurred since that time, we shall find connected with each one of them certain features which undoubtedly mark progress in the art of killing and wounding. Some argue—and on very good grounds, no doubt—that the more sharp and terrible warfare is made the more speedily must it come to an end, and hence look with favor upon the means taken every day to render weapons more destructive and the soldier more cunning in his dangerous trade. We do not propose to discuss this argument, nor to enter at all into any comparison between the wars of our forefathers and those of to-day, but at a crisis like the present we need hardly apologise for bringing before our readers some points illustrating the marked influence of science upon modern warfare.

Starting from the close of the Crimean war, the first in which the electric telegraph was employed, we find ample examples of the assistance furnished to the soldier by scientific research. One instance taken from the war of 1858 is especially interesting. The Austrians held Venice at the time, it may be remember, and to protect the harbor, torpedoes were laid down. The torpedoes were fired by electricity, and contained gun-cotton, this being the first instance on record of the employment of electric torpedoes and of the newly-invented nitro-compounds. Nor was this all. The torpedo system devised at Venice by the Austrian engineers had yet another point of scientific interest. A camera obscura was built overlooking the harbor, and upon the white table of this instrument were reflected the waters of Venice. As the torpedoes were sunk one by one a sentinel in the camera noted the place of their disappearance with a pencil, giving each torpedo a consecutive number. A row-boat in the harbor described a circle around the sunken torpedo indicating the zone of its destructive power, and the sentinel again, with his pencil, made a corresponding ring upon the camera table. In the end, therefore, while the harbor itself was apparently free from all obstruction, a very effective means of torpedo defence was established, the key of which was only to be found in the camera obscura. The sentinel here had wires in connection with every torpedo, and was in a position to fire any one as soon as he observed—by means of the camera—the presence of a hostile vessel within the limits of any of the circles marked upon his white table.

In the American war of 1860, the electric torpedo, invented but two years before, played a most conspicuous *rôle*, and formed indeed, with the use of big guns and monitor ironclads, one of the most important features of the struggle, at any rate from a scientific point of view. The war of 1866, when the Austrians suffered such a terrible defeat at the hands of the Prussians, will long be remembered as a combat between the old muzzle-loading rifle and the breech-loader, in which the latter was victorious. The Franco-German struggle of 1870 again, though marked by the employment of no special arm, if we except the mitrailleuse, was assisted by important applications of science; to wit, the reproduction, by means of photo-lithography, of the French ordnance maps and plans, which were distributed in thousands throughout the Germany army, and the establishment in France of *la poste aérienne* to communicate with the besieged garrison of Paris. The regularity with which the mails left Paris, *par ballon monté*, must still be fresh in the memories of our readers, the publication of correspondence from the French capital being maintained in our journals during the whole period of the investment. From September 23 to January 28, when Paris was practically cut off from the rest of the republic, no less than sixty-four balloons left the city with passengers, mails, and pigeons, and of these only three were lost, while five were captured. The return-post by "homing pigeons" was hardly so regular, but nevertheless half the number of despatches given in by correspondents at Tours and elsewhere, or in other words 100,000 messages, were by the unflagging energy of the postal authorities carried into the beleagured capital. The despatches, most of them as brief as telegrams, were distinctly printed in broad sheets and photographed by the aid of a micro-camera; impressions upon thin transparent films were then taken and rolled in a quill attached to the tail of the winged messenger which was to bear them into Paris. Arrived at their destination, the tiny photographic films were enlarged again by the camera, and the despatches, being once more legible, were distributed to the various addresses.

The present Russo-Turkish war cannot well be less interesting than those that have so recently preceded it, and we may especially point out two directions in which fresh examples of scientific warfare will probably manifest themselves—in connection, namely, with the cavalry pioneer and the Whitehead torpedo. Both of these will probably be seen in warfare for the first time, and before many days are past we may hear of their doings in action.

The cavalry pioneer must not be confounded with the Prussian Uhlan who played so conspicuous a part in the last war. The ubiquitous Uhlan, terrible as he was, did not work the injury which some of the Cossacks will have it in their power to inflict if accoutered as pioneers. These are selected from the smartest and most daring troopers, lightly armed and well mounted. In a belt round their

waists they carry a few pounds of gun-cotton or dynamite, and with this highly destructive explosive they may work incalculable harm. A small charge of gun-cotton placed simply upon a rail and fired with a fuze suffices to blow several feet of the iron to a distance of many yards, thus rendering the railway unserviceable on the instant. A trooper may dismount, place a charge at the base of a telegraph pole, fire it, and be in his saddle again within sixty seconds. Wires may thus be cut and communication stopped in the heart of an enemy's country by fearless riders, who have but to draw rein for an instant to effect the mischief, while lines of railway in the neighborhood are entirely at their mercy. Even light bridges and well-built stockades may be thrown down by the violent detonation of compressed gun-cotton, and forest roads considerably obstructed by trees thrown across, which are never so rapidly felled as when a small charge of this explosive is fired at their roots.

The influence of the Whitehead torpedo, of which we have heard so much of late, will likewise be felt for the first time during the present war. An implement so ingenious in its character that, as Lord Chas. Beresford the other day happily remarked, it can do almost anything but talk, is in the possession of both belligerents, and will doubtless be heard of ere long on the Danube and in the Black Sea. These torpedoes are manufactured at Fiume on the Mediterranean, and, like Krupp guns, are to be purchased by any one who chooses to pay for them.

The British Government manufactures its own Whitehead torpedoes in this country, having paid several thousands of pounds for the privilege. The machinery inside this torpedo is still a secret, which is strictly maintained by our Government, but the principle of the invention is well known. It is a long cigar-shaped machine measuring a dozen feet and upwards. In the head is a charge of some violent explosive, such as gun-cotton or dynamite, which explodes as soon as the torpedo strikes an obstacle. The motive power is compressed air, which is forced into the machine by powerful air-pumps, immediately before the torpedo is discharged into the sea, no less than 600 lbs. on the square inch being the pressure exerted. The Whitehead is shot from a tube, and moves through the water as straight as a dart, the compressed air working upon a screw in the tail of the machine. The delicate machinery permits the torpedo to swim at any depth below the surface that may be desirable, and it flies straight in the direction it is aimed, at a speed of something like twenty miles an hour. If it fails to strike the foe, then the intelligent apparatus at once rises to the surface, becoming innocuous as it does so, and may in this condition be captured without difficulty.

A torpedo of this sort striking the sides of an ironclad would almost infallibly send her to the bottom, and although it has been proved that a network or crinoline around the ship is capable of retarding the progress of a "fish" of this nature, and exploding the same harmlessly in its toils, it is obviously a very difficult matter thus to protect one's craft. Against heavy torpedoes, indeed, there seems no way of defence at all (the Whitehead generally carries a charge of 70 lbs. or 80 lbs., but moored torpedoes may contain a 500 lb. charge), and therefore Turkish vessels will have to give Russian ports a wide berth. All must remember how the magnificent fleet of the French was kept at bay by the torpedoes of the Germans in the North Sea in 1870, and the Black Sea ports are no doubt similarly protected. So demoralizing is the dread of the torpedo with sailors apparently, that they will dare anything rather than venture into waters which conceal these cruel foes.—*H. Baden Pritchard, in Nature.*

PNEUMATIC RAILWAY, LONDON.

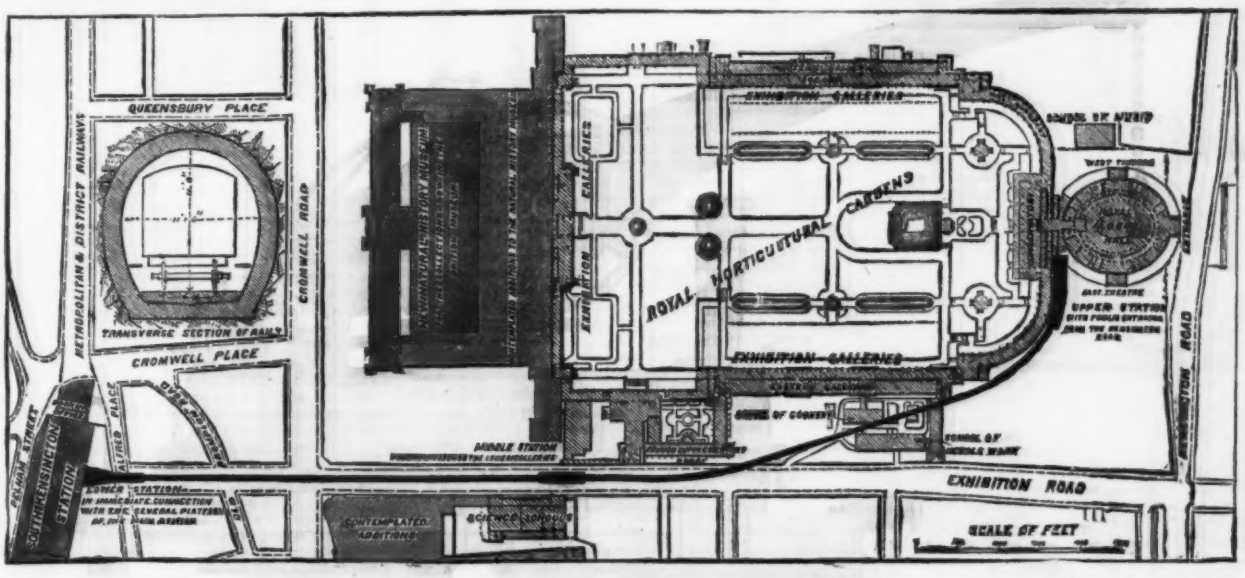
THOSE who visit the South Kensington Museum, the Albert Hall, or the Horticultural Gardens, know that certain difficulties stand in the way. The Metropolitan District Railway is very largely used for the purpose, but it is a quarter of a mile from the gardens, nearly as much from the museum, and half a mile from the Albert Hall. The District Railway Company have found it worth while to run omnibuses to carry passengers over these distances, especially in summer, and it can hardly be disputed that, short as the distances are, the public are quite prepared to pay a trifling sum to be carried over them.

No doubt all our readers are familiar with the pneumatic system of Mr. F. W. Rammell, of Westminster-chambers, in which passengers are blown through a tube by a gentle gale of two or three ounces pressure to the square inch in well-lighted, comfortable carriages, free from smoke, dust, heat, and smell. About 15 years ago this system was tried in Battersea Park on a small scale. Subsequently an experimental line was made and worked in the Crystal Palace grounds. Then, it will be remembered, the pneumatic dispatch line was laid down from Euston to St. Martin, and it was proposed to make a subway from Scotland-yard to the other side of the river near Waterloo terminus. The last two projects have failed, but it is only fair to Mr. Rammell to state that so far as we can ascertain after careful inquiry and an investigation of the system, the failures have had nothing whatever to do with the mechanical principles involved. There is no doubt that Mr. Rammell can blow a train loaded with passengers through a tube, say a mile long, with ease, certainty, and economy, while the passengers will travel with a comfort as regards ventilation quite unknown on the steam-worked underground railway.

A company is now being formed to construct a pneumatic railway between the South Kensington station of the District Railway and the Albert Hall, as shown in the accompanying plan. The line will rise the whole way to the Albert Hall, the ruling gradient being 1 to 48. The train will be blown through the tube by an ejecter, in other words a great centrifugal pump, 24ft. in diameter, fixed close to the District station, and worked by a pair of condensing engines exerting about 170 indicated horse-power. The tunnel is shown in section in our engraving; it will be of brick, and the floor will be paved, and under certain circumstances it will be opened to the public as a dry, well-lighted foot-way, between the Albert Hall and the railway station. Its cross sectional area will be 105·5 square feet; at the end of the train is fixed a screen or piston with an area of 104 square feet, the difference being allowed for windage. The train will consist of six carriages, of very light build, the rail gauge being 4ft. This train will hold 200 passengers, and the total load will be 32 tons, or ten tons less than the weight of a single engine on the Metropolitan Railway. The maximum resistance at twenty miles an hour will be about 2420 lb., requiring to overcome it a pneumatic pressure of 2·6 ounces per square inch, and 162-horse power, assuming the useful effect to be 60 per cent.

No novelty is involved in the scheme, and of its mechanical success we have no doubt. It is quite beyond our province to deal with the commercial success or failure of a railway company, but we may say that the scheme has so far advanced that Mr. Rammell has got together a good board of directors for his company. The capital required is £60,000, and the Metropolitan and District railway companies are supporting the scheme in a very practical way by guaranteeing a 4½ per cent. dividend.

It is worth notice that nearly all the leading engineers in England regard Mr. Rammell's scheme with favor, as will be seen from the fact that a memorial has been addressed to the commissioners for the exhibition of 1851, which runs as follows:



PROJECTED PNEUMATIC UNDERGROUND RAILWAY, LONDON.

"We, the undersigned members of the profession of civil engineers, and others, beg to represent: That we have knowledge of the pneumatic system of propulsion, as applied by Mr. Rammell, and of his long devotion to the working out of the invention. That we are cognizant of his plans for a pneumatic railway at South Kensington, the parliamentary powers for which were granted in 1872, and are of opinion that, apart from the local usefulness of this line, and in view only of the importance of working out practically the principle involved in it, and thoroughly testing its applicability to railway purposes, the undertaking deserves encouragement and support from her Majesty's Commissioners.—Signed, Charles Hutton Gregory, M. Inst, C.E., W. H. Barlow, James Brunlees, T. Hawksley, F. J. Bramwell, John Coode, William Pole, Joseph Whitworth, J. W. Bazalgette, James Abernethy, Edward Woods, George R. Bruce, C. William Siemens, E. Frankland, Harrison Hayter, George Berkeley, J. Fredk. Bateman, William Haywood, Latimer Clark, George Robert Stephenson."

With such an array of evidence in favor of the scheme, it is impossible to doubt the merits of Mr. Rammell's plans.—*Engineer.*

(Continued from SUPPLEMENT No. 83.)

A RAILROAD IN THE CLOUDS.

By J. EGLINTON MONTGOMERY.

Thus much for the picturesque and descriptive part of our task. We proceed now to give a slight history of the great enterprise. Don Manuel Pardo, previous to his being President of Peru, was obliged to seek some climate that might restore his health, and he found it in the province of Jauja. "In this rich part of Peru," says Mr. Hutchinson,* "his stay was turned to good account by a pamphlet† which he published, containing his observations on its wealth of minerals, and on the railways that by this route may cross the Andes, as well as open up the interior resources of the republic. In this brochure he discusses the subject of peopling the valleys of the Amazon, and argues against the error of supposing that this ought to be done, as far as Peru is concerned, by medium of that river which flows through much of Brazil." * * * "The further purpose of the pamphlet is to advocate a railway from Lima to Jauja, which is considered the most salubrious province in Peru, and where magic cures of the aggravated forms of phthisis pulmonalis (consumption) have been effected. It may be seen by the map," continues Mr. Hutchinson, "that the Oroya line now in progress is the first step toward accomplishing this great work, originally suggested by Don Manual Pardo." But to General Pedro Diez Canseco has usually been accorded the credit of having conceived the great project. The honor, however, of practically working out the plan, by whomsoever proposed, is due to our countryman, Mr. Henry Meiggs, whose perseverance, indomitable energy, and great executive ability have been fully equal to the task he has undertaken. He has been assisted by an able corps of engineers, among whom Mr. L. Malinowski, the chief engineer, had much to do with the selection of the route. Mr. Meiggs contracted to build and equip the entire road for the sum of 27,600,000 soles, or about $200,000 a mile, and he stipulated to have the line in good running order in six years from the date of signing the contract, provided the government should meet its obligations. The great cost of this undertaking, and of other enterprises of equal magnitude in which the government has been engaged, has seriously embarrassed it in a time of such general financial depression as the present, so that Mr. Meiggs' far-reaching plans have not been fully accomplished.

The sum allowed Mr. Meiggs for building the Oroya Railroad may seem very large in comparison with our own roads, which average only about $60,000 a mile; but it does not very greatly exceed the total cost per mile of the railroads of Great Britain, which amounts to about $170,000. The contract included everything connected with the survey, construction, and right of way, besides the furnishing of all supplies, the building of necessary docks at Callão; of station, freight, and engine houses, and the supplying of a certain number of engines, coal, freight, and passenger cars—in fact, the whole equipment of a first-class railway. The rolling stock has been imported from the eastern workshops of the United States, the rails from England, and the cross-ties from California. All the plant for the construction of the road had to be transported by mules, and the cost of new mule-paths to replace those occupied by the rails, as they advanced, is estimated to have been $500,000. At one time there were 850 mules and 150 horses in the employ of the company, and the transportation cost was 8,000 soles a day. The road-bed has been made in the most secure manner, and its upper-structures are of the best materials. The striking characteristic here, as with everything else done by Mr. Meiggs in Peru, is the perfect adaptation of the work to its end. Besides innumerable bridges, there are 61 tunnels, aggregating 20,000 feet in length, and a majority of them are built upon curves of a minimum radius. The powder alone for blasting purposes amounted to 53,250 quintals, or over 5,000,000 lbs., and cost about 750,000 soles. One part of an embankment near the Verrugas bridge contains 90,000 cubic yards of material. The natives, as a class, were not friendly to the road, and the right of way had often to be purchased at a cost very much beyond the value of the land.

Nothwithstanding the great care and attention paid by Mr. Meiggs to the well-being of his workmen, who have been principally Chilians and Chinese, at least 10,000 persons are computed to have died thus far in the progress of the work. An intermittent fever of a very malignant character broke out in 1870 and 1871 among the Chilians employed between the Cupiche bridge and Coracona, and scarcely one in a hundred recovered. A disease peculiar to the valley of the Rimac, although less fatal than the so-called Oroya fever, has occasioned great suffering and inconvenience. A bloody wart or excrescence comes out upon the skin, and while it lasts, and even before it appears, the system is greatly depressed, for the warts often bleed profusely, and men have been known to come in from their work with their boots filled with blood. It has been supposed to be caused by the water of that region. The soroché has also very much hindered the progress of the work, and especially of that part lying along the higher elevations.

Mr. Meiggs has a lease of the road at 6,000 soles per month, and he pays all expenses and keeps the rolling stock in good repair. It is directly under the supervision of Mr. Cilley, who, as superintendent, conducts it in a very efficient manner. Mr. H. J. Kingman is the road-master, Mr. H. P. Tobias, the resident engineer, and Dr. George A. Ward, the attending physician, attached to the road. These gentlemen are all Americans, and conduct their several departments with great skill and judgment.

* Taken from a letter without signature, in Herndon's "Explorations of the Sources of the Amazon."

† "The Andes and the Amazon; or, Across the Continent of South America." By James Orton, M.A.

We have been accustomed to consider the railway over the Alps and the tunneling of Mont Cenis as a very great achievement. But that ascent was made by only six zigzags, and at the culminating point the tunnel is but 4,236 feet above the sea. Therefore the Oroya Railroad must take rank in the history of modern engineering as a work of the first magnitude, without a rival. It has been urged that this distinction has not been attained without entailing a very serious burden of debt upon the Peruvian government if the road should not be a commercial success. Even if this should be the case, and the road should continue no farther than Cerro de Pasco, that branch line must ultimately connect with the valley of the Chanchamayo, a region of extraordinary fertility, by a road which must be remuerative. Thence to the Amazon by the valley of the Ucayali would not be very far. When Mr. Meiggs made the contract for the first Peruvian railway, in 1868—that between Mollendo and Arequipa—Peru was very far behind other nations, and especially her sister republic of Chili, in the matter of internal improvements. There was no community of interests between the various divisions of her territory. The whole country was stagnating for the want of development—and that where every climate might be enjoyed, from tropical warmth to Arctic cold; where the earth yields, in abundance, cotton, rice, tobacco, corn, and every known variety of fruit and vegetable, and many medicinal plants; and where unknown wealth is stored up in mines of gold, silver, copper, iron, lead, and coal, besides cobalt, nickel, platinum, quicksilver, saltpeter, and mercury. Peru possesses a rich heritage in the basin of the Amazon, for there Nature works on her largest and most prodigal scale;* there she annually wastes as much, it is said, as would feed the whole population of China; "The Amazon," says a recent writer;† "drains a million more square miles than the Mississippi," and within its capacious valley "the whole of the United States could be packed without touching its boundaries." To leave her share of this magnificent domain undeveloped would be fatal to the best interests of Peru, and, indeed, a loss to the world; for when the native tribes of the Montaña shall disappear, as they must, before the advance of civilization, and shall be replaced by industrious and skilled laborers from Europe, Asia, and the United States, it is impossible to estimate how great will be the gain to commerce from the opening and cultivation of this bountiful land. The time is yet far distant, it may be, before this end can be attained; but steam alone can hasten the day, and bring unity to a nation as divided by natural barriers as Peru. As to the ultimate result of the great highway across the continent of South America, Mr. Bates, an enthusiastic British naturalist, who lived for seven years on the banks of the upper Amazon, has, in advance of the enterprise, suggested a future of magnificent possibilities: "Although humanity," he says, "can reach an advanced state of culture, only by battling with the inclemencies of nature in high latitudes, it is only under the equator that the perfect race will attain to complete fruition of man's heritage—the earth."‡

In the meantime, as we do not yet possess that complete balance of the mental and physical powers which would warrant us in seeking a residence in this equatorial paradise; and as one cannot always

> " * * poise about in cloudy thunder-tents,
> To watch the abysm-birth of elements,"

we retrace our way to latitudes in which the vicissitudes are such as to insure the attainment of a perfect culture. And what a retracing of the way! A mere railway-carriage is but a rude mode of descending from the clouds. Might we gratify the aspirations raised by the upward journey, we would fain make for the downward trip

> " * * a ladder of the eternal wind;"

or we would bestride a captured thunder-bolt. But, alas! these elemental conveyances must give way to the more practicable, though perilous, hand-car. Thus it is, that in a material age, every adventurous American returns over the Oroya Railroad, down the declivities of the rugged and formidable Cordillera.

At Anchi, 12,000 feet above the Pacific the hand-car is loaded with its freight of six adventurous sight-seers, closely braced together. It is of the ordinary construction and appearance, and does not offer any temptations to a pleasure excursion down the precipitous and tortuous gorge of the Rimac, except that it affords an unobstructed view of the shifting grandeur and terrors of the route. As we descend in our tough vehicle, at the rate of 60 miles an hour; flying across aerial viaducts, or dashing through sepulchral tunnels; threatened, now, to be crushed between converging mountain walls, or precipitated from pendulous terraces—the foaming Rimac emulating the maddening speed; now glancing back to take a last look at the glistening pinnacles of the receding Andes; or, straining eagerly forward to catch the first glimpse of the royal city of the plain and the shining ocean—the magnificence of the scenery and the magnitude of Mr. Meiggs' achievement break upon us with fresh force, and not for any peril of the way would we forego the exhilaration and novelty of the trip. Far otherwise was it with one of the party—a stately commodore. He, who could face unflinchingly a whole broadside of murderous missiles, sprang from the car after ten miles over the wildest part of route, declaring that nothing would tempt him to repeat such a fool-hardy experiment. For the rest of us, the excitement and exhilaration of this mode of travel became so attractive that we often went up to Anchi for the sole purpose of making the down trip.

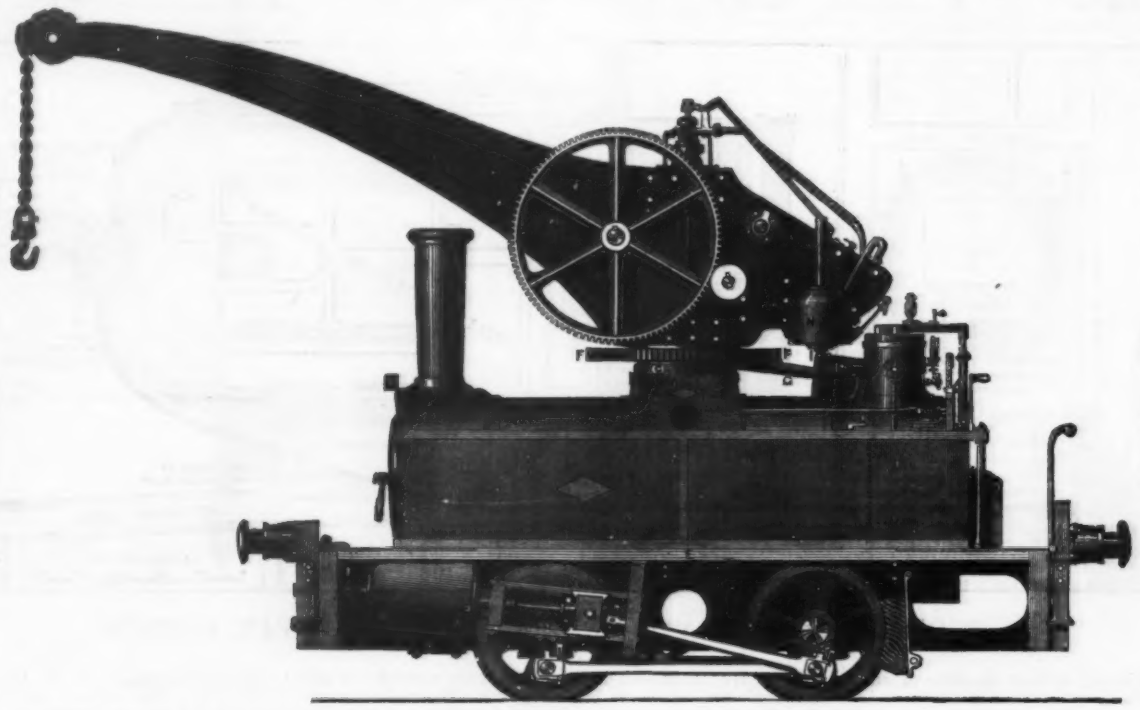
It will be seen that a railway over the Andes is virtually an accomplished fact. There must be a force inherent in this portion of the American continent which compels to Herculean labors. The Cordilleras themselves were not produced from the bosom of the ocean but by mighty throes; and where the lofty Illampu crowns the chain, the powerful empire of the Incas arose, amid arid wastes and frigid desolation. More than twelve thousand feet above the sea, two bleak islands of Lake Titicaca are covered with dilapidated temples and palaces, and terraces whose flowers once bloomed on a soil that had been brought, it is said, four hundred miles; and a fountain still flows with water conducted from unknown sources. A thousand feet below is Cuzco, the once famous city of the sun; and to this day, it reflects in its cyclopean walls the ambitions and polity of Incarial rulers, who had pleasure grounds and palaces in the valley of Yucay, encircled by mountains still terraced to the summit of vanishing heights, and still fortressed on dizzy crags and forbidding passes. In the midst of the Thibet of the new world, Tiahuanuco was the center of an empire even more remote, and its ruins represent a civilization possibly contemporaneous with that of Egypt.* Even in its ruins, it excites the wonder and admiration of the traveler, who compares them not unfavorably to Stonehenge and Avebury. Remains as vast and impressive are to be seen on the dreary dunes of the coast. Is it strange, then, that men of the present, surrounded by such colossal formations, natural and artificial, should come under the sway of the same irresistible power; and that they should vie with the past in the stupendous character of their undertakings?

* "Two years in Peru."

† "Estudios sobre la Provincia de Jauja."

‡ "The Naturalist on the Amazons." By Henry Walter Bates.

* "Peru: Incidents of Travel and Exploration in the Land of the Incas." By E. George Squier, M.A., F.S.A.



LOCOMOTIVE RAILWAY CRANE. GLASGOW LOCOMOTIVE WORKS.

LOCOMOTIVE RAILWAY CRANE.

In the new crane engine, designed by the late Henry Dubs, Glasgow Locomotive Works, of which we now give an engraving, the main frames A are carried up to the base of the pillar, which base is a wrought-iron slab B, 2¼ in. in thickness, on which there is planted the crane post C. The engine is capable of lifting weights of 2½ tons with a jib range of even 14 ft. in length. The platform or tank support is made of thick cast iron so that it may be used to form a counterbalance to the weight being lifted; and by increasing the weight of this counterbalance it is very easy to make such an engine as we have figured to lift even much heavier loads.

There is a slewing arrangement consisting of the worm-wheel F operated by the worm G, which is worked by means of a separate engine; and there is this advantage attending its working, namely, that all the operations are referred back to the footplate, and are under the direct control of a single workman. At the hinder part of the crane there is a tank H for collecting all water from the waste-water cocks of the crane engine, etc. Such an addition is especially desirable in cases where the engine is used upon a platform or staging underneath where men may be working. The tank is so arranged that when it is full its contents can be discharged by means of a large cock into the side tanks of the locomotive. A couple of these 2½ ton crane engines are in constant use at the works of the Steel Company of Scotland, at Hallside, near Glasgow. They are chiefly employed for setting the casting pits. Each crane has from 4,000 to 5,000 lifts per week, the work including the lifting of ingots, ingot moulds, slags, etc., changing the ladles, loading the scrap, etc. Another of the same type has recently been made for the Panteg Steel Works, near Pontypool. One capable of lifting 7 tons was sent some time ago to Moscow, and one of smaller lifting capacity has been supplied to the harbor of Libau. Altogether there are now about a dozen of them in use. For such work as we have already referred to, as also for harbor works, bridge building, quarry work, timber yards, timber ponds, etc., they are eminently serviceable.—*Engineering.*

TREATING OXIDES OF IRON.

The residual oxides of iron, and more particularly that known as purple ore, resulting from the burning of iron pyrites, are not well adapted for direct employment in the blast furnace, and the invention of Mr. Duncan McKechine, of St. Helens, Lancaster, consists in submitting the oxides of iron after lixiviation (subsequent to the separation of copper and silver from the residues of burnt pyrites) to the action of an elevated temperature in a kiln or kilns constructed in the following manner, so as firstly to effect the desiccation of the same; and, secondly, the agglomeration of the finely divided iron oxide. The kiln is composed of any suitable number of chambers, all capable of being placed as required in or out of communication with a flue for the passage of the products of combustion by opening or closing dampers below, in each of which chambers are constructed any desired number of fireplaces or chambers, the same being separated from the main chamber by a floor or partition. In this floor are formed a series of apertures which admit of the heated gases and products of combustion from the fireplaces ascending into the interior of the chamber. Before charging the incorporated materials into the kiln or chamber, the same being uncovered, or partially so, planks, slabs, or cores composed or constructed of wood or other suitable material are placed vertically over the apertures in the floor, and after the kiln or chamber has been charged the planks, slabs, or cores are withdrawn, and the kiln or chamber having been covered or closed with the roof, the heated air and gases ascend into the interior of the kiln or chamber, the spaces left by the withdrawal of the planks, slabs, or cores forming flues for the traverse of such heated air and gases. The firing or heating of the contents of the kiln or chamber is continued until the incorporated materials assume the desired consistence, when the agglomerated material may be allowed to cool, and be then broken into the desired size or forms suitable for being employed in a blast furnace or otherwise for the production of iron. In order to effect such cooling process and to utilize the residual heat, he prefers to cause air to pass through the passages of the consolidated iron ore.

HYDRAULIC COAL MINER.

The latest addition to the various systems introduced for the purpose of breaking coal *in situ* is that just brought out by Mr. Joseph Mitchell, Worsborough-dale, near Barnsley. The invention consists of an expanding plug of a cylindrical form worked by means of hydraulic pressure. The plug is composed of two halves, with a little wedge-shaped space between them, and are jointed at the end to the extremity of a hydraulic cylinder, and receive between them a wedge-shaped extension of the hydraulic ram or plunger, fitting exactly the widest part of the wedge-shaped space, and extending about half its length when the ram is withdrawn into the hydraulic cylinder. When the pressure is applied to the ram, the wedge-like extension is driven further along the space between the two halves of the plug which are forced apart, so that the plug is expanded in one direction beyond its original diameter. As usual, the coal is undercut in the ordinary way, when a hole is drilled in the face of it corresponding to the size of the plug in its contracted form, into which is inserted the plug, so that the expanding force will be exerted in a vertical direction, and the hydraulic power being applied, the wedge is driven between the parts of the plug, expanding the latter until the mass is brought down.

PNEUMATIC CLOCK.

THE pneumatic clock, here illustrated, is the invention of Herr Ingenieur A. C. Mayrhofer. The principle of this invention may be briefly described as follows: It consists in working and controlling a large number of dials, whose wheelwork is of the simplest construction, by means of one central, accurate, and powerful clock, which the inventor terms his "normal Uhr." The said normal Uhr can be itself, when desired, subject to daily correction from an astronomical observatory, by means of electricity. At intervals of time of one minute or two, to either of which the apparatus can be set, the normal Uhr opens and closes the communication between the air reservoir and the floats of the various dials, by means of a three-way cock, R, Fig. 1, or slide valve, both means being found to give good results. The compressed air on being thus admitted presses with equal force, and practically at the same moment, in all the mains and branches with which the reservoir is in connection, and causes the floats in the mercury tubes—see N, Fig. 5—to rise. Each float carries with it the movable arm O, whose center is coincident with that of the ratchet wheel Q. To this moving arm is attached the adjustable pawl W, with weight C, the pawl being so attached that it shall engage either one or two teeth of the wheel at every stroke, according to whether the air is admitted every minute or two minutes. The ratchet wheel having moved forward, the fixed pawl R prevents its return; the ratchet wheel has sixty teeth, and the minute hand of the dial is attached to its arbor, the hour hand being driven from a pinion on the same arbor by the arrangement known to clockmakers as the "dial work."

From the above it will be seen that each dial shows the time indicated by the normal Uhr, by the following simple mechanism, *i. e.*, the float, concentric lever with pawls, ratchet wheel, two ordinary wheels, and two pinions, which four latter form the dial work; and in the case of a turret clock four dials can be worked from one and the same float and ratchet wheel. It is evident from the above that the actual application of pneumatics to horology is simplicity itself, and it is merely the normal Uhr, with the air compressing, reducing, and regulating apparatus as designed by Herr Mayrhofer, which seems rather unnecessarily complicated. The following is an outline of its construction: The air is compressed to about two atmospheres by means of a double-acting pump, driven by a Lenoir gas engine, and is delivered into a cylindrical reservoir of boiler plate, 10 ft. high by 4 ft. diameter, from which reservoir it is led off by an in-pipe through the reducing valve G, Fig. 3, passing on through the outlet pipe H, to the remainder of the apparatus. The action of the reducing valve is as follows: The piston valve E is supported by the float D on the surface of the mercury; the height of the mercury itself depends on the pressure in the working reservoir, in which a pressure of about one-half an atmosphere should exist. The instrument having been correctly adjusted, it is evident that if that pressure is exceeded the mercury will rise in the lower part of the reducing apparatus, carrying with it the float and valve, which will prevent the passage of more high-pressure air, until the pressure in the working reservoir has again failen. The glass tube K forms a simple pressure gauge. The working reservoir is of the same dimensions as the high-pressure reservoir, with the exception that it need not be made of such strong plate.

On leaving the working reservoir the air passes through the drying chamber, Fig. 4, which contains quick lime; the lime absorbs any water that may be in suspension in the air, and so prevents the deposit of water in the mains or branches, which would, of course, be fatal to accurate time. From the drying chamber the air is led to the three-way cock R by the tube J, Figs. 1 and 2, which cock is turned at intervals, as before said, by mechanism somewhat similar to the English striking work of the clocks, and by a simple arrangement of cam, not shown in the drawings, the cock will be turned every half minute or every minute; it will be seen that the cock moves once for each admission of air to the mains, and once for each emission; it remains open in the first case about fifteen seconds, allowing ample time for all the floats with which the mains are connected to rise; the crank which opens the cock remains on its outer center in the one case, and on its inner center in the other case. The means of driving the clock will be best understood by referring to Figs. 1, 2, and 6; the weight M1 drives the going part of the clock, the weight M2 drives the control port; both weights are supported by the opposite bights of an endless pitch chain, whose course is easily traced round the sprocket wheels A C F and V, round the four fixed idle pulleys in the clock frame, and round the four moving idle pulleys Z Z Z Z on the four weights, of which the two smaller serve merely to keep the chain tight. By means of the two levers W and W1 attached to pistons of different diameter, W1 having three times the area of W, the ratchet wheels are turned through a portion of a revolution at every admission of air to the mains, with which the under sides of the piston are in connection. The ratchet wheels carry with them the sprocket wheels F and V, and so wind the clock. The small piston and lever W wind direct by the up stroke, whereas the large piston and long lever wind by the intervention of gearing on the down stroke by means of a heavy weight attached to the end of the lever. The ratio of the aforesaid gearing being such, that though lever W1 is considerably longer than W, still the circumferences of the two sprocket wheels on axles T and V move through equal arcs in the same period of time, and thus the normal lengths of the bights of the chain remain constant, and the clock continues to go on so long as there exists any pressure in the working reservoir. It is obvious that any number of dials up to some thousands can be worked from the same normal Uhr, as the expenditure of air is extremely trifling. It is also equally clear that all the hands of these dials will move forward at practically the same moment, and for those towns in which the pneumatic post already exists the apparatus is capable of exceptionally cheap application, as an arrangement can be made—and is now under consideration in Vienna—to supply compressed air to the clock from the postal reservoir, by which means the cost of erecting special air-compressing machinery is avoided.

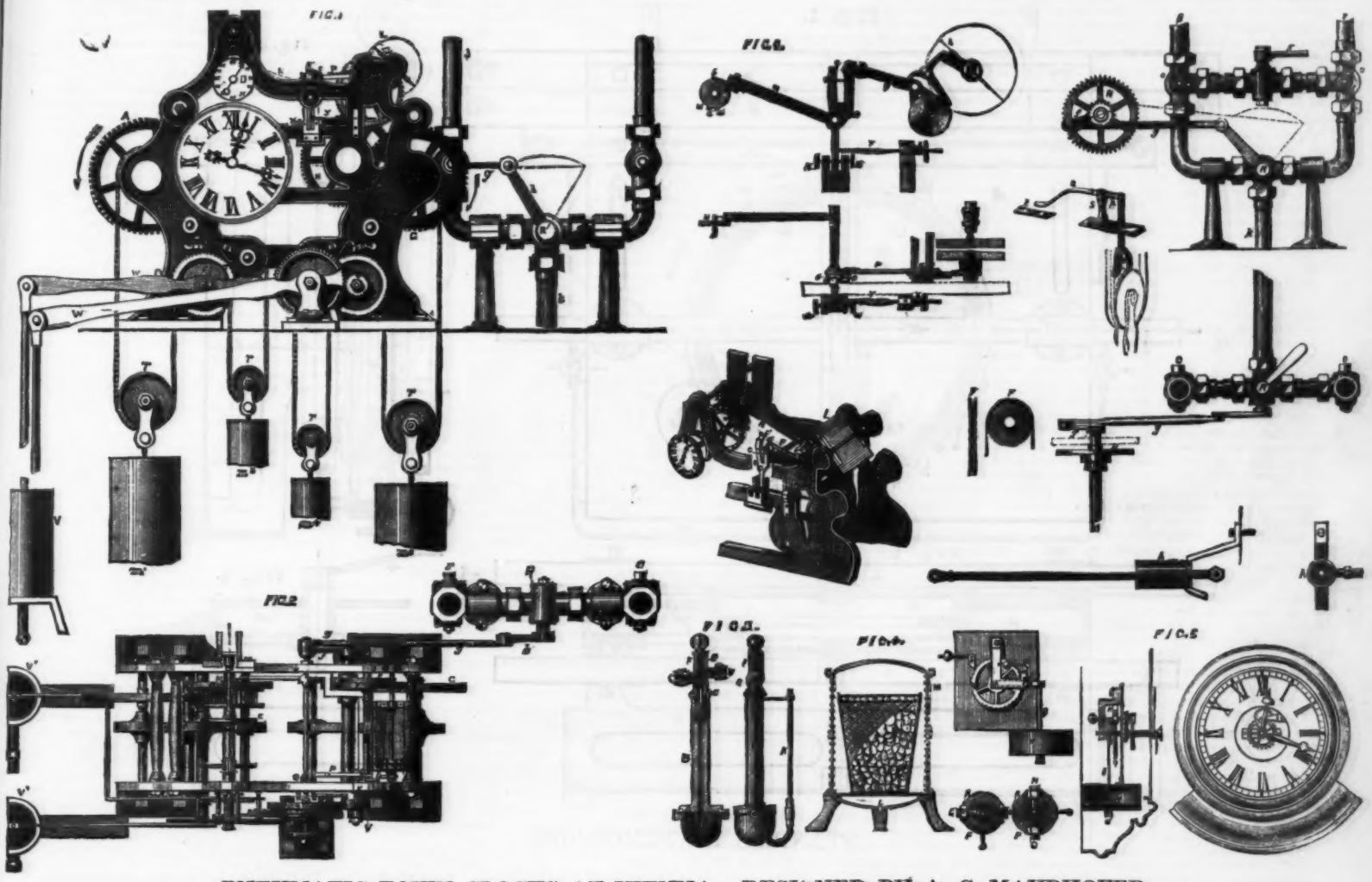
Pneumatic-driven striking dials are also being made, in which the going part resembles Fig. 5, the spring which drives the striking part being wound at every admission of air by the same piston which drives the going part—on the same principle as that already explained. A snail on the hour-hand arbor regulates the number of strokes, according to the English striking method. Such a dial is really a curiosity, as, from the fact of the spring being so constantly wound, very little wheel-work is visible, and a 10 lb. weight bell is well struck by mechanism which seems too light for one of one-fourth the size.

The street mains consist of lead pipe 1 in. in internal diameter, which is large enough to work several hundred dials. Bricks of a U section are made to inclose the piping, and to protect it from road pressure and mice. About ten clock dials are now connected to the normal Uhr in Vienna, and arrangements are rapidly being made to connect a much larger number, and to erect a large number of dials in the Ring-Strasse. The invention has stood a test of about four months in Vienna, and has given great satisfaction.

One point worthy of notice with reference to the arrangement here described is that the instruments and dials will work with a greatly varying pressure of air. 5 lb. per inch being sufficient, while 15 lb. are not too much. and the object of the reducing valve—before described—is to permit the gas engine or other motor to remain at rest, if necessary, for twelve hours, without affecting the going of the clock, as it will be observed the speed of the hands on the dials is entirely independent of variations in pressure. The apparatus is being introduced in Paris, and will shortly be erected there.—*The Engineer.*

IMPROVED GAS FURNACES.

AT a recent meeting of the Society of Engineers, at Liége, an interesting paper descriptive of Bicheroux's gas furnace system was read by Mr. Raze, the general manager of the Ougrée Iron Company. All the heating and puddling furnaces at Ougrée are now worked by gas on Bicheroux's system. Formerly there were 27 ordinary single puddling-furnaces, which have been supplanted for the same production by 15 gas furnaces, each with two working doors. The 27 ordinary furnaces required 108 men for day and night service, 54 being master puddlers. The 15 gas furnaces now only require 90 men, of which 30 are master puddlers. The work at the gas furnaces is much lighter than at ordinary furnaces. The saving of coal at Ougrée since the general adoption of the gas furnaces amounts to 30 tons per day,



PNEUMATIC TOWN CLOCKS AT VIENNA. DESIGNED BY A. C. MAYRHOFER.

and the coal used now is of an inferior kind, therefore cheaper. The apparatus consists of three parts—a gas producer, where only a small quantity of air is admitted through the grate for the production of carbonic acid; a mixing chamber, where this gas and air is collected by the natural draught, and where the combustion of the gas begins; and a furnace or laboratory, where the combustion is nearly completed, and where the different reactions in the puddling process takes place. The dimensions of each of these three parts vary with the composition of the different coals, and the system can be applied to all kinds of coal, even to such which, from being small and slatey, are not suitable for ordinary puddling. The gases and air necessary for their combustion being brought together at different temperatures, and having to be drawn into the mixing and combustion chamber by the same chimney, it is easily understood that the dimensions of their conduits must vary with each kind of coal, and that the manner of bringing them together is not unimportant. Before the air arrives at the intermediate chamber it is allowed to circulate beneath the bottom of the furnace, and in the sides of the chamber itself, in such a way that the advantages of heating the air, as well as that of cooling such parts of the furnace which cannot be heated without injury, are obtained. The gases which leave the furnace not completely burnt are utilized for the heating of the boilers as in ordinary furnaces. The management of the fire is very easy, waste is diminished, the usual dimensions of the furnaces are increased, and there is a working door on each side. With regard to economy, Mr. Raze states that with the ordinary furnaces the puddling of ordinary white Ougrée iron required 18 to 20 cwts., whilst it is now done with 12 cwts. per ton of bars produced. Fine-grained iron, which required 26 to 30 cwts., is now puddled with 16 cwts.

THE DIANEMOSCOPE.

MR. STANEK'S "dianemoscope" has for its object the analysis of the more complicated motions of a double slide valve system.

The circular disks B and C can be turned around their geometrical axes either separately—if the screws D D are loosened—or as one piece if these screws are tightened. Each disk has a radical groove, and the sliding pieces E and F, which move in these grooves, can be fixed in any distance from the center. Connected with E and F are two other sliding pieces G and H, moving in slits attached to two rods K and L, which are guided at M M. When the disks B and C are turned, the rods K and L will move to and fro in the guides M M, and it is evident that their stroke will vary according to the position of E and F. Together with these rods, two sliding rulers P and O are moved (being connected with the slits), whereas a third ruler N is fixed to the framework of the instrument and remains therefore stationary. Each ruler has suitable screws Q, to hold paper strips which may be fixed to the rulers.

The circular disk B, whose motion can be arrested by the set screw R, bears on its circumference a movable pointer T, which can be fixed in any position as the case may require. The circular disk C has a toothed circumference corresponding with the teeth of the pinion S, to which a handle *a* can be attached on either side of the instrument, serving to turn the pinion S, and by it either the disk C alone, or both disks C and B.

Along the grooves in C and B scales of millimeters are engraved, whereas on the framework around the disk B a circular division (in degrees) is marked. Finally, lines are drawn dividing the diameter of B in ten equal parts (these lines are marked 1, 2—9 in the engraving). The fixed pointer U marks the zero point of the circular division. The whole apparatus rests in a suitable chair W in such a manner that either side can be turned upwards. If required, the apparatus can be taken out of this chair and placed upon the table, when it will be supported by the legs Z. Now, the fixed ruler N represents the face of steam chamber, the ruler O represents the main slide valve, and the disk B its eccentric, whereas the expansion valve with its eccentric is represented by the ruler P and the disk C. Finally the pointer T represents the crank pin.

By this apparatus the action of any slide valve gear can be investigated where either one or two slide valves are used, but it is of special use where two slide valves—one moving on the back of the other—are applied, in which case the relative movements of both valves become somewhat more complicated, and a special apparatus to represent these movements is desirable. The well-known diagram of Zeuner gives an easy means to determine the proportions of such a double valve gear. To study its action more minutely, however, it is always preferable to have the motion of both valves brought before the eye in the same manner as they occur in the engine itself. This purpose is attained by the use of Mr. Stanek's dianemoscope, which in fact is but a model of the real valve gear. Its use is the following:

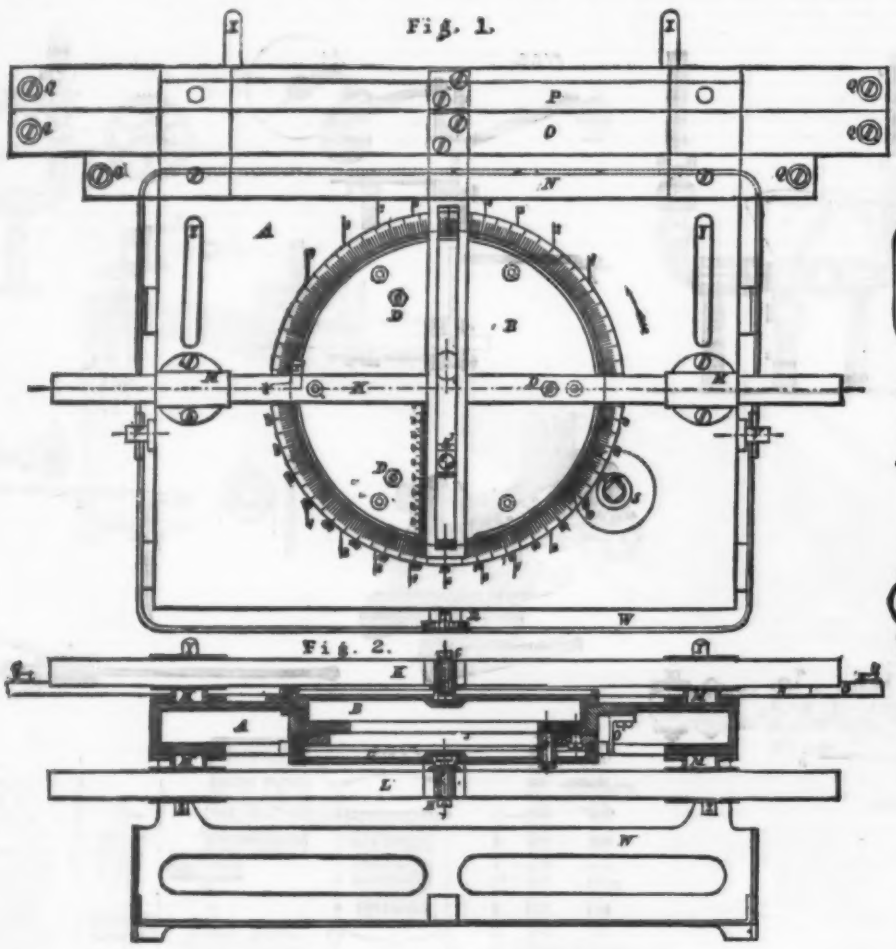
Let us suppose that there is to be examined a double slide valve gear (*e.g.* Meyer's system) of these dimensions:

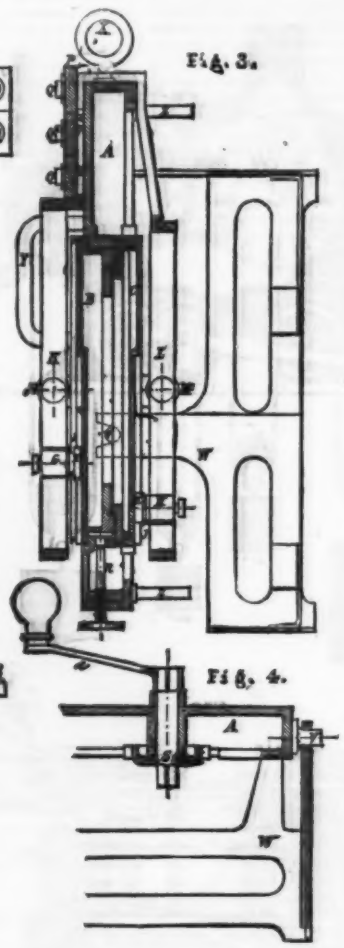
$m°$ = angle between crank and main eccentric.
$n°$ = " " " expanding eccentric.
$2p$ (millim.) stroke of main slide valve.
$2g$ (millim.) " expanding valve.

First turn the disk B by means of the handle *a* until the center line of its groove coincides with the mark of *n* degrees, and arrest it in this position by the screw R. Then turn the apparatus so that the disk C is on the upper side, loosen the screws D D, and turn the disk C by means of the handle *a* (which must be, of course, transferred always to the proper side of the instrument), until the center line of the groove of C corresponds with the pointer U. This done, the screws D D are again fastened. The sliding-piece F is then placed at a distance of *g* millimeters from the center of the disk C, the instrument is again turned round, and after the screw R is loosened, the disk B (and of course C together with it) is turned until its groove reaches the zero point (viz., the pointer U). Then the pointer T is shifted until it corresponds with the mark of *m*° degrees, and is fixed in this position. Finally the sliding-piece E is fixed in the distance of *p* millimeters from the center of B.

Now it is only necessary to mark the leading dimensions of both valves and of the steam ports in the cylinder on three paper strips, and to fasten these strips by means of the screws Q Q upon the respective rulers N O P. Thus the apparatus is ready for use. Then on turning the handle *a* the motions of the rulers O and P will correspond exactly to the motions of the actual slide valves, whereas the pointer T will show the position of the crank pin, and, by means of the division marked on A, also the position of the piston. This division, by which the diameter of B is divided in ten parts, depends, of course, on the proportion of the connecting rod to the crank. In the figures the division is shown for a connecting rod of infinite length (the usual supposition in Zeuner's diagrams), but, besides these, other marks could be also made corresponding to other proportions, *e.g.*, $\frac{1}{4}$ or $\frac{1}{5}$.

If the lap of the upper slide valve is variable (as *e.g.* in Meyer's gear), the varying lengths can be marked on the respective strips of paper, and the instrument will then show the exact positions at which steam is cut off with various lengths of lap, or *vice versa*, these lengths can be found by setting the pointer T to the required position of the crank where steam shall be cut of, and then the length of the expanding valve or length of lap can be measured directly on the paper strip representing this valve. In a similar way many other questions can be decided in an equally easy and lucid manner, and we need only add that the instrument has done good service in the offices where it is employed.—*Engineering.*





STANEK'S DIANEMOSCOPE.

MATCHES.

By JOHN A. GARVER, A.B.

DURING the whole of the last century, and in the early part of the present century, the invention of a safe and trustworthy agent for furnishing fire was regarded as one of the great wants of the age; and fifty years ago a tinder-box was as much an indispensable article of household economy as is the well filled match safe to-day. The sulphur match now in use is not so old as our railroads, and but a few years ago there occurred frequent examples of burns caused by the explosion of the match and the projection of its burning pieces.

Among the more civilized nations, the tinder-box, with the flint and steel, became known in the fourteenth century, and continued to be used, notwithstanding the other methods, down to the invention of the lucifer match. The tinder was formed by the partial combustion of a linen or cotton rag, and, being ignited by striking a spark upon it from the flint and steel, communicated its fire in turn to the match.

When phosphorus was first discovered, two hundred years ago, it was utilized in London by rubbing it between two pieces of brown paper. A fire was produced in this way, which lighted a splint tipped with sulphur. Another early method was to put a piece of phosphorus in a vial and stir it with a hot iron wire, after which the vial was corked tightly for use. As the phosphorus was partially burned in the confined portion of the air, the interior of the vial became covered with oxide of phosphorus. When a light was desired, a sulphur-tipped splint was dipped into the bottle, a portion of the phosphorus adhered to it, and, being brought into the air, the chemical action between the two substances caused a flame which lighted the splint.

When chlorate of potash is mixed with loaf-sugar, a drop of sulphuric acid let fall on the compound will produce a brilliant flame. This principle involved the next stage in the development of the match. The end of the splint was tipped with the mixture, colored with vermilion, and ignited in a little bottle containing asbestos and sulphuric acid. The various ingredients were then put into a handsome metal case, and the patent was ready to take its place among the wealthy; for, at first, a single case of a hundred sold for four dollars and seventy five cents.

There were certain drawbacks to the practical use of this invention, as the acid would become weak by absorbing moisture from the air, and the match, instead of producing the brilliant flame expected, merely smouldered and spurted the acid about, to the detriment of good clothes and a peaceful disposition. As a stroke of economy, such a wetted match was occasionally put back among the rest for future use; but, coming in contact with one more energetic, it ignited the latter, and thus the whole collection was lighted at once and shot out in all directions. From this dip splint, oxymuriate match, or instantaneous light-box, as it was variously termed, lucifers trace their lineal descent.

John Walker, an Englishman, is generally supposed to have invented lucifer matches in 1829. The first real friction match was made in England in 1832, and was a compound of chlorate of potash and sulphuret of antimony. It was ignited by strong compression between two pieces of sandpaper, and, as a natural consequence, the heads flew frequently off in all directions. A year or two later, phosphorus was substituted for the antimony; the matches were called "congreves," and the composition continued to be improved by using other constituents for part of the chlorate of potash.

The ease with which phosphorus is ignited by friction has caused it to be employed universally in the manufacture of matches. The particular proportions and the exact ingredients which make up the head of the match are jealously guarded by the manufacturers, each one claiming some advantage over the others. From one twelfth to one tenth is laid down as the best proportion of phosphorus to be employed. Glue, gum, or similar substances, are used for causing the composition to adhere to the splint. The use of glue is objectionable, as it carbonizes and prevents combustion. In preparing the compound, the mucilaginous substance is dissolved in water till it assumes the consistency of thin sirup. After it is heated, the phosphorus is added in small pieces, and thoroughly incorporated by rubbing till cold. If it were left in this condition, however, the mass, upon becoming cold, would prevent the admission of air and hinder combustion. Some additional substance is necessary to supply the oxygen to it, such as red lead, saltpeter, or chlorate of potash.

Coloring matter is also usually put into the solution: vermilion, if the tips are to be red; Prussian blue, if they are to be blue, etc. In making sulphur matches, the ends of the splints are first dipped into melted sulphur, and afterward touched to the surface of the phosphorus paste. In lighting such a match, the process is as follows: the coating of the head is broken by friction, the phosphorus is kindled, and the heat of its combustion decomposes the salts; these, in

their decomposition, evolve oxygen, which provides the fuel, increases the heat, and causes the ignition of the sulphur, which in turn inflames the wood. The temperature required for kindling matches varies from 150° to 160° Fahr. The sulphur is what causes the peculiar brimstone odor. Instead of sulphur, stearin, stearic acid, or paraffin, is used in the better kinds of matches. They burn more readily than the sulphur matches, as the fatty matter and wood take fire together, while in the others the sulphur must first be consumed before the wood is ignited. The matches soaked in fatty matter also burn with a clearer and brighter light, and are free from the disagreeable odor due to the sulphur. A coating of varnish is sometimes employed to protect the head from moisture.

Before a box of matches can be sold, it has passed through about forty different processes, twenty for the matches and as many for the box. The wood used for the splints is commonly white pine, free from knots. Other woods are also occasionally employed, as beech, birch, willow, poplar, and cedar. Much of the wood for this purpose is brought from Canada, and the match manufacture is assuming such large proportions that it is making serious inroads into the supply of clear white pine timber needed for other purposes. Formerly, the splints were cut by hand, and the composition was applied by the same means. Separate factories are now commonly employed for making the splints, and the entire labor is performed by machinery. As the manufacturers do not allow visitors in their buildings, it is impossible to describe exactly the machinery or the methods employed. By one process, the pine wood is reduced to two-inch planks, which are cut into blocks the length of the ordinary match. These are put into a small machine, which at each stroke cuts off twelve splints, and at the following stroke delivers them upon an endless chain, which carries them to a sulphur bath, where a wheel, revolving in the sulphur, coats their ends as they pass; farther on, a similar wheel applies the phosphorus. In this condition the matches are brought back across the room, delivered in trays near the cutting machine, and thence sent to the packing room. In wax matches, or vestas, the composition is attached to a few cotton threads immersed in a mixture of paraffin and stearin. One or two hundred of these wicks are rolled around a cylinder and separated by a comb. They pass through a bath of melted wax, and are afterward drawn through holes in a metal frame, which renders the tapers smooth, cylindrical, and of the proper size and shape. A mechanical knife cuts, at one time, all the wicks according to the determined length, from one to one and a quarter inch, after which the paste is applied to their ends with great rapidity.

In the manufacture of matches much trouble has been occasioned by the use of phosphorus, as its fumes attack the teeth of the workmen, and give rise to a disease known as caries of the jawbones. In some of the small and poorly managed factories the men and children are never free from the fumes; their clothes and breath are luminous in the dark, and in the daytime white fumes may be seen escaping from them whenever they are seated by the fire. The phosphorus first attacks a decayed tooth, causing pain which constantly becomes greater. The gums are sore, the face swollen, and the teeth finally drop out. The suffering is excruciating, the patient finds little relief for months or years, and in a severe case, there is loss of one or both jawbones, hindering mastication and ending in death. So alarming did this disease become in Germany at one time that it attracted the attention of the Government. No antidote has yet been discovered, but it can be prevented to a great extent by ventilation and cleanliness. We have inquired of several of the leading American manufacturers in regard to the subject, and all say that their workmen are not troubled in this manner. No examination of their teeth is enforced, the men being merely warned as to the consequences before they begin their work.

Partly as a remedy for this evil, the red or amorphous phosphorus was substituted for the ordinary variety. This possesses neither odor nor taste, is not poisonous, and can be handled with safety. The danger arising from the use of matches was magnified, because they could sometimes be seen in the dark, were liable to ignite on a warm shelf, and were poisonous to such an extent that children had been killed by using them as playthings. From red phosphorus resulted the safety match. Many attempts were made to form a paste with red phosphorus and chlorate of potash without success, and finally the paste and phosphorus were separated. The heads now consist of a pasty mass, composed mainly of sulphuret of antimony and chlorate of potash. The red phosphorus, mixed with very fine sand or other substance, is glued to the box in which the matches are contained. It is impossible to light such matches by friction upon any common rough surface, though they at once burst into flame when rubbed upon the phosphorus composition on the box.

They can sometimes be lighted without application to the phosphorus on the box, by drawing them several times with long sweeps over such surfaces as glass, ebony, etc. When they were first introduced into England, the use of any other kind in the public buildings was forbidden by a special act of Parliament. Their manufacture has been encouraged in several European countries, and in times past their use has by some Governments been enjoined by law. These matches are also called "hygienic," because they can be put into the mouth without danger.

Another kind of safety match, which has never come into general use, contained the phosphorus at one end and the chlorate of potash at the other. The match is lighted by breaking it in halves and rubbing the two ends together.

In Switzerland, safety matches are almost the only ones in the market, and in Sweden they are largely manufactured for exportation. A firm in New York imported the latter for many years, but the customs duty was so high, and the demand was so slight, that the business was abandoned. One of the former partners stated that, if the American people would show any desire for the matches, he could furnish them much cheaper than the matches produced in this country, as in Sweden the materials are provided at a very trifling expense. But, as he expressed it, "an American prefers to put his hand into his pocket, take out a match, and strike it on his pantaloons or shoe, to economizing by carrying them around in the box in which he buys them. And you could never get the Irish servants here to use safety matches unless you had the priest on your side."

Factories for the production of safety matches were established in New York, Boston, and other places, but they have all failed with the exception of one in Erie, Pennsylvania, which, with the assistance of some of the wax and parlor manufacturers, easily supplies the demand created in this country. Those made by Bryant & May, in England, are also found in the shops here. The great objection to safety matches seems to be due to the fact that they are so difficult to carry about. In France they are regarded with great disfavor by the population. No one cares to be troubled with an angular box which he must hold in his hand till he has lighted his match; and it is impossible to put the phosphorus compound on a small pocket match safe, as the surface is not sufficiently great, and the phosphorus soon rubs off.

A gentleman who has been employed in the manufacture of safety matches expressed it as his opinion that they are the most dangerous matches made. For in the majority of cases, when a match is struck, some of the phosphorus on the box flies off, and, being highly inflammable, if it meets with any combustible substance, it always give rise to a danger of fire. If lighted where the phosphorus can fall upon the carpet, the result is the same as though the carpet were exposed to the sparks of a fire. There is also a certain degree of temptation offered to those who manufacture these matches. This consists in putting a small quantity of phosphorus into the heads to make them ignite more easily when brought into contact with the phosphorus on the box. This fraud has actually been carried into effect in Northern Germany, and, although nothing of the kind has been discovered in this country, the fact that it may be will probably increase their unpopularity.

The safety match has certainly had time to win its way, as an old variety of it existed in Switzerland at a period when other parts of the world were still occupied with the flint and steel. It has been claimed for these matches that they are better able to resist moisture than other varieties. The reason, however, is not apparent, as the heads are composed of salts, which are affected by water in the manner of all saline substances. It may be stated as a general rule that those matches are safest which require considerable friction for ignition, and which, when lighted, furnish merely heat enough to kindle the splints. The safest, probably, are those in which a considerable part of the compound is formed of sulphur, as it requires more than usual friction to light them. They are also a quiet match, and in lighting do not scatter any part of the head about. But they kindle slowly, and the sulphurous fumes always render them objectionable. They can also be lighted so conveniently, by rubbing them on the wall, that a great temptation is held out to servants to disfigure the appearance of a room in this way.

About twenty years ago parlor matches began to be manufactured, and have ever since been growing in favor. No sulphur is used in them, and in their freedom from odor, their convenience and rapidity in lighting, they have a decided advantage over all others. Their noisy explosion is occasioned by chlorate of potash, and may be prevented by substituting nitrate of potash. They are said to be superior to the German match, owing, perhaps, to the fact that they are not coated with varnish. They seem to have attained their greatest popularity in the Western and Southern States, and are used pretty generally among the wealthier classes. Swift & Courtney, who have factories in four different cities, manufacture about 1,500 gross of these daily, and state that the demand for them is constantly increasing. They are nearly half again as expensive as the sulphur match, and grocers and retail jobbers are inclined to increase their price. There is, however, but a small difference between the cost of matches with sulphur and those in which stearic acid is used, as much more sulphur is required than stearic acid. They partake of the same danger that attends the employment of the safety match, for if they are tipped too profusely the burning material will scatter to some distance. They take fire easily if any one happens to step upon them, and require to be guarded carefully where there are children. But the danger from their use is not alarming, and insurance companies make but little distinction in their rates between these and others. It is a mistaken idea that the invention of matches has caused much difference in the number of fires; and, if a certain kind of match is preferred for its convenience, it will not be abandoned because it has an extra element of danger. Fires may result from the overturning of a box by a cat or dog, or by the gnawing of the ends of matches by rats or mice; but these occurrences are exceptional, and rarely happen.

There is said to be only one factory in America where wax matches are now produced. This has been established within the last few years, is running altogether with French machinery, and is supplying a growing demand. The makers of wax matches do not come into competition with other manufacturers, but find their custom among those who are attracted especially by the novelty and pleasing appearance of the matches. Their higher cost prevents them from coming into general use, and the fact that there is a monopoly in their manufacture exerts some influence in regard to the price.

Great care is taken in the designs for the boxes, and no pains are spared to make them ornamental and attractive. Improvements and new patents are constantly being made in them. The most recent variety has a small hole in the lid which acts as a candlestick. As soon as the match is lighted, the unburned end is inserted in the lid of the box, and an illumination is provided which lasts according to the length of the taper. The usual wax match gives a fine light, which continues one or two minutes—that is, four or five times as long as wooden matches. This can be increased with their length, and a very respectable impromptu candle may be obtained by the contrivance referred to. Further attractions are provided by arranging the differently colored heads according to curious and artistic devices. They can be purchased, having a composition resembling the parlor match, or in the form of safety matches. All wax matches must be made so that they will take fire upon slight friction on account of the less resistance afforded by the body of the match. But they are not on this account any more dangerous than the parlor match. Though sometimes used by smokers, they are not well suited to this purpose, as in lighting a cigar the fatty matter can be detected by the taste.

The Japanese have contributed their stock of curiosities to this department also. They have a variety of paper matches, which burn with a small, scarcely luminous flame, forming, as the combustion advances, a redhot ball of glowing saline matter. When the match has been partly consumed, a succession of bright sparks shoots out from the head, and gradually a brilliant scintillation is formed similar to that observed in burning a steel spring in oxygen, only much more delicate, the separate sparks branching out in beautiful forms. These matches are composed of carbon, nitre, and sulphur, and there has been no difficulty in imitating them.

Many efforts have been made to construct the heads of matches without phosphorus. There is a match in Germany at the present time in which this result has been reached, but none of the cases discovered seem to be perfectly satisfactory. Dr. Jettel has made a careful examination of the subject, and has arrived at the conclusion that the ingredients prepared to take the place of phosphorus render the match more difficult to ignite, while they are not perfectly harmless, but merely less dangerous. They are more sensitive to moisture; it is more difficult for the maker to secure a satisfactory result; and hence more expensive for the buyer. The Germans in nearly all their matches use a much smaller proportion of phosphorus than is done elsewhere, but the material must yet be found which will take its place entirely.

Accidents may be occasioned by throwing half-burned matches carelessly aside, and allowing them to smoulder near combustible substances. Various chemical solutions have been compounded in which the match is to be soaked, so that, as soon as it is blown out, the mass of fiery carbon will become black. Solutions of this kind are alum, borax, Glauber salts, or Epsom salts. Matches thus prepared are, of course, rendered more expensive.

While so much has been accomplished in the way of getting a quick fire without exertion, there is still room for considerable improvement. A safety match has yet to be invented which will contain the entire composition on its own head. A waterproof match is desired, but has never been invented. There are firms which represent that they make waterproof matches, and the scientific journals contained from time to time receipts to effect this purpose. But they are not proof to water in the sense in which that is generally understood.

Most matches may be put into the mouth or dipped into water for an instant, but none of them will bear a drenching or continued exposure to a moist atmosphere. The safety match is objectionable for several reasons, the parlor match from its tendency to scatter about bits of the head, and the sulphur match from its brimstone odor.

Matches have been made in which camphor and frankincense were mixed with the paste, and the wood of the match was of cedar, so that an agreeable odor was diffused in getting a light. So the time may come when the fashionable match, in addition to its other excellent qualities, will have such a delicate fragrance that it will be a pleasure merely to light it.

In 1864 the Government required a one cent stamp to be placed on every package of matches. In anticipation of the tax a large quantity had been manufactured, so that for the first two years the legitimate revenue was not derived. In 1865 the receipts obtained in this manner amounted to about $1,000,000, but since then they have greatly increased, so that the stamp tax now forms a large part of the cost. In comparison with other branches of business, this product of industry probably affords the largest revenue accruing under the excise. Owing to this tax several large firms either failed or retired; and at the present time the manufacturer of sulphur matches, by the greatest care and economy, secures but a small margin on his sales. A heavy tax of this kind is liable to defeat its own object, as is exemplified by numerous facts. Thus, in 1865, matches were imported into the United States from New Brunswick, and sold in packages suitable for the retail trade without paying any tax under the internal revenue law. When, a few years ago in England, a stamp duty was put upon matches, the opposition was so violent that the attempt had to be abandoned.

In 1872 the French Government, desiring an additional source of revenue, determined to extract it from their matches. They therefore let to a single great company the sole right of making them for twenty years, and agreed to buy up all the old factories and furnish the company with new ones. In return, the latter was to pay a fixed rent of $3,200,000 per annum. It was furthermore stipulated that the price of the matches should not be raised, but the company is already accused of treating this as a dead letter. The matches are said to be so bad that they will hardly light, and the peasants, instead of buying them, use a match of home manufacture, made by steeping hemp in sulphur. Great trouble and expense have been incurred by the State; the company has been despotic and unable to fulfil its obligations; a proposition has been made and rejected on the part of the Government to reduce the rent one half; and the probabilities are that the lease will expire before the time agreed upon.

The extent to which the manufacture of matches is carried can be but faintly indicated by means of figures. The demand for them in Great Britain is, on an average, eight daily for each individual; in Belgium, nine per head; and, for Europe and North America, the entire average is six for every inhabitant. To meet this demand matches are produced by the million, and the waxed taper, before division into small pieces, is measured by the mile. It is stated that one pound of phosphorus is sufficient for 1,000,000 matches, though the proportion varies greatly.

In France there are consumed for this purpose 70,000 pounds of phosphorus every year. The largest makers are in Austria, two of whom use twenty tons of phosphorus per annum, and produce nearly 45,000,000,000 matches. One firm in New York uses annually 700,000 feet of choice white pine timber, 100,000 pounds of sulphur, and 150 tons of straw board for their boxes. Large quantities are exported from the United States to the East and West Indies, China, South America, and other countries. At the census taken here in 1870 there were found to be 75 establishments engaged in the business, and the value of the products for that year was $3,540,000.—*Popular Science Monthly.*

MANUFACTURE OF PORTLAND CEMENT.

AN important improvement of Portland cement has been patented by Messrs. White, of Swanscombe, England, by which a better quality of material is obtained and the cost of manufacture is considerably reduced. For this purpose they take chalk and clay in the natural state in which they are found, and without the admixture of water they obtain an intimate mixture of these materials by placing them together into a hopper, from which they pass to a series of pairs of crushing rollers. The materials as they leave the hopper have first to pass through a pair or pairs of fluted crushing rollers, from which they pass to other pairs of plain rollers, placed closer and closer together, and running at increased surface speeds. By this means the materials are reduced to a thin sheet, the chalk within which is in a thoroughly disintegrated state and mixed with the clay. After the materials have thus been crushed and mixed together by means of rollers, they may be moulded into bricks to be burnt in any ordinary manner, no fuel being mixed up with the materials of which the cement is composed.

The number of pairs of rollers in the mixing machine may be varied, but they prefer five, and the relative dimensions and speed of the rollers may also be varied. In the most convenient arrangement of machine there is a hopper at the top, into which they feed the materials, chalk, and clay in proper proportions and in the raw state in which they are obtained. The materials descend from the hopper to a pair

of horizontal rollers fluted longitudinally. These rollers are (say) about 12 in. in diameter at the points of the flutes, and are adjusted to work at 13 in. apart from center to center and to make about 10½ revolutions a minute. From these rollers the materials descend by preference to a second pair of fluted rollers of about the same diameter placed closer together—say, about 11½ in. from center to center, and making about 24 revolutions a minute. From these the materials drop to a pair of smooth rollers about 1 ft. 3 in. in diameter, 3-16 in. apart, and making (say) 39 revolutions a minute. From these again to another pair of rollers placed still closer together—say about 3-32 in. apart, 1 ft. 9 in. in diameter, and driven at about 58 revolutions per minute. All the above rollers we have made 3 ft. long. From the last-mentioned rollers the materials drop to another pair placed still closer—say about 1-32 in. apart, 2 ft. 3 in. in diameter, and driven at still greater surface speed—say 88 revolutions per minute; they are also set at right angles to the other rollers and are made about 4 ft. 6 in. long The stream of materials descending on to these rollers from the rollers above them becomes doubled or gathered together, and is thereby intimately mixed together; a very perfect mixing of the materials may, however, be obtained even if the last pair of rollers are placed in a line with the other rollers and not at right angles to them. A scraper is, by means of a weight or spring, or any other suitable method, held up to the under side of the several rollers to prevent the material being carried round with them, and at the ends of the spaces between the several pairs of rollers there are end plates which prevent the material from escaping and compel it to pass downwards between the rollers.

The several rollers are geared together by toothed wheels at their ends, so that they shall revolve together at the required speeds, and be driven by a belt wheel on the axis of one of the rollers. The lowest pair of rollers may be driven by a separate belt and belt wheel or ordinary gearing. The materials having thus been mixed together in the machine are afterwards moulded into bricks or blocks to be burnt. They prefer to use for this purpose that class of machine in which the materials are fed by rollers into a box across the bottom of which a series of moulds formed in a revolving table are caused to pass in succession; the moulds are filled as they pass below the filling-box, and are emptied after passing beyond the box, but other machines for moulding bricks or blocks may be used for the purpose. All that is required is that the machine should perform its work quickly, no perfect moulding of the bricks being required so long as they are about the same size, and will hold together to allow of their being stacked in a kiln.

It will be seen that by the hereinbefore described process of making cement the ordinary addition of water to the materials is entirely dispensed with, and consequently the tedious and costly process of draining and driving off the water which has been so added is done away with, a result which has before been aimed at, but not attained.

THE MONNIER PROCESS AT THE PROVIDENCE MINE.

PERHAPS no mining enterprise in California is watched with more interest, at present, than that now connected with the well-known Providence quartz and sulphuret mine, on Deer Creek, near Nevada City. Experts call it "a new departure" in the mining interests of the Pacific States.

Mr. J. W. Wright lately examined the establishment, and writes as follows to the *Mining and Scientific Press:*

This valuable mine is owned by Messrs. Walraths & Hunter. During the last six months they have been preparing for the introduction on this coast of this new method of reducing ores, and for more than a week past their works have been in successful operation. This is the method of reducing refractory ores by roasting and lixiviation, as invented and patented by Alfred Monnier.

Being kindly afforded every facility to investigate this method of extracting the precious metals, so entirely new to our coast, I shall try, by aid of the Professor's explanations, and the accompanying diagram I have made of the ground plan of the works, to give your readers some idea what this methods is, how it differs from, and what its advantages are over the usual method.

These works are on a steep hillside. Going from A, the highest point, to B, the lowest, you descend from floor to floor to some 20 feet. The shaft and hoisting works are about 100 feet to left of point 1. The order of arrangemnt of cylinder, tanks, arastras, etc., will naturally vary according to the surface to be built upon.

1. Lump ore, from mine. 8. Sulphate of Soda. 2. Rock-breaker and crusher. 3. Elevators which carry crushed ore and soda to 4. Receptacle of same, whence, through 5, they are conducted into 6, revolving cylinder, where the mixture is roasted. 7. Fire-box of cylinder. 8. Lixiviating tanks. 9. Reservoir for lixiviating tanks. 10. Reservoir for strong solution. 11. Feeder for evaporator. 12. Evaporator. 13. Crystallizing tank. 14. Arastras. 15. Feeder for copper plate in 16, amalgamating trough. P. Roasted and lixiviating ore ready for arastras. S2. Sulphate of soda taken from crystallizing tank. *b*, point where iron car receives roasted ore. *t*, tramway over which car passes to lixiviators.

What are known among miners as

"REFRACTORY ORES,"

are those containing a large proportion of metallic sulphurets. The method long in vogue in what are called the "sulphuret works" of our mining regions, is that of *chlorination*, where common salt, manganese, and sulphuric acid are used, and must be purchased for the purpose. The Monnier method for the treatment of metallic sulphurets may be correctly distinguished from the former as the method of *sulphatization*—a term suggested by Prof. Monnier—since its chemical processes consist in changing into sulphates the sulphurets of different metals contained in the quartzose ore.

The Messrs. Walraths and Hunter have been working their mine about six years, reducing the ore by the common method of chlorination. Their shaft is down something more than 800 feet, with the usual drifts every 100 feet. Some 20 men are now at work in the different drifts, and the ore brought up daily is a very fine quality of sulphurets. The chemical compounds it contains, besides the pure silica of the quartz, are sulphurets of silver, copper, iron, zinc, and lead, containing gold, also small quantities of arsenic and antimony. That portion of the ore which is reduced by

THE MONNIER METHOD

is treated as follows:

The crude dry ore in lumps (1) is mixed with sulphate of soda (5) and passed by the shovelful into the rock-breaker and thence between Cornish rollers (2). The proportion of the mixture is 20 lbs. soda to 80 lbs. ore. Through one elevator (3) the crushed mixture passes to a wire sieve with 24 holes to the linear inch, *i. e.*, 576 to the square inch. From this sieve the coarser particles return by a chute to the rock-breaker, the finer pass through it into a second elevator (3), which conducts the finely pulverized and dry material into a large box (4), whence it is passed regularly through a small chamber of brick and iron into the huge revolving iron cylinder (6), which is five feet in diameter by 40 feet long.

THE ROASTING

is here accomplished. This cylinder is revolved very slowly by water power. Its upper end (*a*) is raised six inches above the level of the lower end (*b*). This elevation can be increased, according to the proportion of sulphur in the ore. The cylinder has now been revolving without intermission for a month. Its slow motion causes the roasting mixture to gravitate gradually towards the lowest level, and some 12 hours are required for the crushed sulphates to pass from the upper to the lower end of this revolving cylinder. It thus contains at one time about seven and one-half tons of the ore, since about 15 tons are reduced by this method every 24 hours.

An intensely heated draft of air passes steadily from the fire-box (7) into the lower end of the cylinder. The mixture is thus heated to a high degree, until at the lower end (*b*) the ore reaches a dark red heat. This roasting within the cylinder gradually transforms the sulphurets into sulphates and the gold is set free. Chemically this is explained by the sulphur becoming oxidized and

FORMING SULPHURIC ACID.

This combines with the soda, forming a bisulphate of soda, the decomposition of which reduces successfully the sulphurets of iron, etc. A considerable quantity of sulphurous acid is also formed and escapes from the cylinder. The resulting sulphates being soluble in water, you can look with safety from the upper end of the cylinder through its entire length, and see myriads of brilliant scintillations flying to and fro, and falling like so many meteors in miniature. These are caused by the union of sulphur with the oxygen from the atmospheric air. The degree of heat required is maintained by consuming in the fire-box *half a cord* of mountain cedar each 24 hours. The red hot ore passes at *b* of ore, besides the water needed to dissolve the sulphates of silver, copper, and soda.

We will now return and see what becomes of

THE RESIDUE OF INSOLUBLE MATTER

left in the lixiviating tank. It consists of silica, pure gold, and sesquioxide of iron, also a small amount of silver with sulphate of lead. When the liquid has been drained from it, it is shoveled out on the platform (P), from which it is passed into the surface (14). After mixing with water and thorough grinding it runs into the feeders (15)—which act also as reducers of the remaining sulphate of silver—and thence through wooden spigots and troughs into the broad, shallow, and long troughs (16), provided from point to point with boxes or catchers of pecullar construction. The bottoms of these troughs and boxes are covered with amalgamated copper plates. Here

THE GOLD

is so free it is immediately taken up by the quicksilver, and with the remaining silver is secured in the form of an amalgam, while the residuum, containing oxide of iron, passes outside of the building to a large wooden tank. From that the oxide is collected in a still larger tank, where it settles, and is collected and dried. Mixed with oil this

OXIDE OF IRON

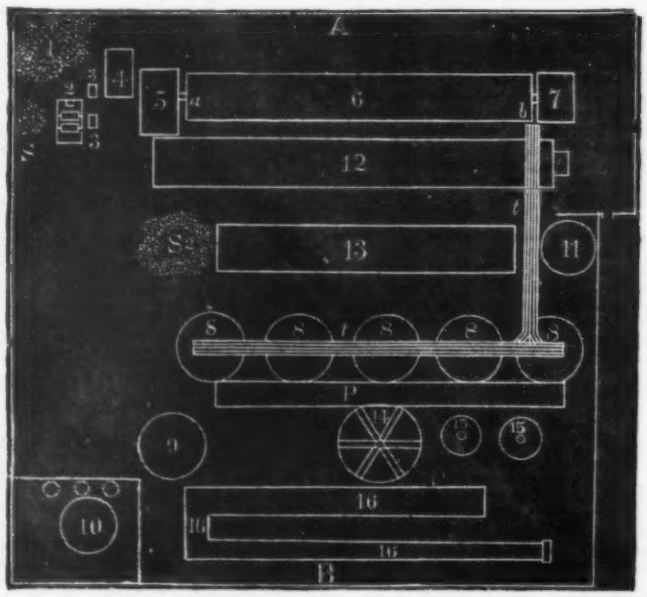
makes the purest of metallic paints—its natural color reddish brown—and is the very best that can be used on all iron structures. By combining different ingredients with it various colors can be produced. It makes a first-class fire-proof roof paint.

ADVANTAGES OF SULPHATIZATION.

We shall close this description by stating some advantages of sulphatization over chlorination, as is proved at the Providence mine.

By chlorination much of the coarse gold may be lost, and no silver can be saved. Sulphatization usually saves from 92 per cent. to 95 per cent. of the gold, and leaves it in such a free state that quicksilver takes it up at once.

To chlorinate gold some 48 hours are generally required. The method of sulphatization requires but 12 hours.



GROUND PLAN OF PROVIDENCE REDUCTION WORKS.

into an iron wheelbarrow, which is trundled by one man along a tramway (*t*), passing over five huge wooden tanks (8), made on the Monnier plan, and partly filled with water at its natural temperature. Here

THE PROCESS OF LIXIVIATION

begins. The man who handles the wheelbarrow takes the roasted ore from it by the shovelful and drops it into any one of the lixiviating tanks. Quite a detonation follows as each shovelful is thrown in. This is continued until each tank receives its allowance.

By a set of rubber tubes connection is kept up between the liquid in three of the tanks at a time, thus forming a battery.

When the water in any of the five tanks holds in solution the largest possible amount of sulphates of silver, copper, and soda, it is sent by a tube into small tanks filled with cement copper by which the silver is precipitated. Thence the remaining liquid is run into a reservoir (10). This is done in what is called

THE SILVER ROOM.

Any weaker solution is passed into another reservoir (10), to be used again in lixiviating till it attains sufficient strength.

From the reservoir (10) the solution is conducted by a wooden pump and trough into a tank under tank 11. Thence it is raised by a wooden pump into the latter tank, which serves as a feeder for the evaporator (11). This huge evaporator is filled through a wooden trough from tank 11, and the liquid in it is kept at boiling heat by the hot air passed into it from the revolving cylinder and the fire-box.

After a certain time allowed for evaporation the remaining liquid is passed by rubber syphons from the evaporator into the crystallizing tank (13). This tank now contains only sulphates of copper and soda in solution. As the liquid cools, the sulphate of soda crystallizes, and is drawn out by an iron hoe with a long handle into a pile (S2), to be used over again to repeat the process *ad infinitum*. The amount lost is scarcely appreciable.

THE COPPER

in solution is then precipitated by iron. All the round tanks are about the same size, having a capacity of some 700 cubic feet. The five used for lixiviating each hold 25 tons

Chlorination extracts gold only. This "Monnier method" extracts gold, silver, copper, and oxide of iron. Then these better results are obtained at a great reduction of expense in labor and fuel, and the expense of buying sulphuric acid, manganese, and salt is avoided. It takes one man at the roasting cylinder in the Monnier process, and *half a cord* of wood, in twelve hours, to sulphatize *fifteen* tons of ore, when by other processes, such as chlorination, it takes three men and one cord and a quarter of wood for one ton and a quarter of ore.

The only material purchased in sulphatizing is sulphate of soda at a trifling expense, while the method produces its own sulphuric acid. As has been shown, the soda can be used again and again with scarcely any loss.

When we remember how rich in sulphurets are the almost exhaustless quartz leads of our mountains, we can scarcely overestimate the value of this successful introduction of Prof. Monnier's method on the Pacific coast.

The Professor informs me that the application of the re-revolving cylinder in this method is new and far surpasses expectation. As to the other apparatus, it has been brought step by step to its present state of perfection by its use in the Eastern States in the treatment of 14,000 or 15,000 tons of sulphuret ores.

NEW METALLIC ALLOY.—An alleged method of producing alloys has been invented by Mr. Frank Raymond, of Greenville, South Carolina. It consists in melting mica and mixing the same with any metal or composition of metals while the same is being melted, thereby rendering the metals harder, admitting of better finish, preventing corrosion or rust, less susceptible to effect by fire, heat, or friction, and more durable. He proposes to take of mica the quantity necessary to produce the desired effect, and a relative quantity of borax, saltpetre, and soda, or either or any two of them, and place the same in the crucible or furnace, together with the necessary quantity of metal or metals, and melt the whole in the usual way. The borax, saltpetre, and soda will cause the mica to melt, when it will mingle with the metal or metals in the crucible or furnace, producing the effects mentioned. In carrying the invention into operation, the ingredients have been compounded in the following proportions: Lead, one part; mica, two parts; also brass, three parts; copper, one part; zinc, one part; lead, one part; mica, four parts; also copper, four parts; mica four parts; tin, one part; lead, one part.

ON CATARRH.

BY DUDLEY OLDS, M.D., Professor of Ophthalmology and Otology, in the Louisville Hospital College of Medicine, Senior Surgeon to Louisville Eye and Ear Infirmary.

THE term catarrh is one that has been generally applied to all forms of acute inflammation of the membranous lining of the air passages. Professor G. B. Wood, in his "Practice of Medicine," devotes the last chapter of the first volume to the consideration of the subject of catarrh, and he defines it as being "any acute inflammation of any of the mucous membranes of the body, not due to traumatic causes." As we usually see catarrh in practice, catarrh affecting the lining of the nose, the upper part of the throat, the Eustachian tube, and the cavity of the tympanum, the cases in the earlier stages of the disease rarely present themselves for treatment, except that class of persons who suffer from catarrhal inflammations invading the middle ear.

It is a well-known fact that a very large majority of the persons who suffer with impairment of the hearing are affected with catarrh, afflicted with an inflammation which is usually due to the inhalation of poisoned air. It was very clearly, unmistakably, and undoubtedly established by Schonbein, in 1851, in his experiments with electricity, that powerful currents of electricity passing through the air decompose the oxygen, and develop a substance called ozone, which is said to be an allotropic form of oxygen. Ozone was demonstrated by Schonbein to be possessed of power to irritate the air passages sufficiently to develop the inflammatory processes of varying degrees of intensity, in proportion to the amount of ozone in the air and the duration of time occupied in the inhalation. It was noted on divers occasions, by astronomers, that whenever powerful currents of electricity occur, along with sudden elevations of temperature, there is general complaint from epidemic influenza, which is just another name for catarrh.

We all remember what was called the epizootic, which prevailed in the winter of 1873 and '74. The epizootic was a kind of catarrh or influenza which affected the inferior animals. It is precisely the same cause which produces naso-pharyngeal catarrh as we find it in our daily practice. The simplest form of catarrh is that in which there is an afflux of all the circulating fluids in the membranes, with augmented secretion. That gives rise, of course, to considerable swelling and consequent obstruction to breathing, and we find that, whereas the nasal passages were perfectly free a few moments ago, now they are so entirely closed that we are obliged to open our mouths to breathe. If you examine a case of that sort of catarrh, you will find there is a very slight increase in the general redness of the membrane, without the destruction of all of its transparency, the blood vessels in the mucous membrane being clearly and distinctly visible, at the same time the venous trunks greatly distended and engorged. There is hyper-secretion of mucus, and along with this hyper-secretion of mucus is found, in many instances, an exudation of serum from the surface. There is a set of glands in the mucous membrane lining the nose known as acinous glands, which afford a secretion precisely identical in appearance and in chemical composition with tears. At the same time the lachrymal glands are irritated. There is a greatly increased secretion of tears, and when the catarrh affects the nasal passages, extending up through the nasal duct into the lining of the eyelids, we have what is called coryza. That means acute catarrh, affecting not only the nasal passages, but the conjuctival membrane as well.

We usually see cases of catarrh that have existed for some time. They are not apt to present themselves for treatment until the disease has shown a disposition to linger, because catarrh is one of those forms of disease that attacks almost all animate nature. It attacks everybody that breathes air —every animal that breathes air is liable to acute catarrh, and these attacks often disappear of themselves, without treatment.

Catarrhal inflammation, like any other localized inflammation, has a natural tendency to recover after running a definite course. But on account of the complicated character of the nasal passages, and the liability of the secretions to be retained in the ramifications, we find a steady disposition upon the part of this particular membrane or lining of the nose to suffer from chronic forms of disease—a special disposition upon the part of catarrhal diseases to linger in the nasal passages. It sometimes fills the naso-pharyngeal space. It remains confined to that particular locality, in many instances, for weeks, months, years, and from the naso pharyngeal space it travels the Eustachian tubes into the middle ear, and produces destructive changes in the wall of the tympanic cavity, before the presence of catarrh is even suspected. With the aid of the rhinoscope, catarrh limited to the naso-pharyngeal space may be discovered. The peculiar conditions of the membrane may be readily understood by bringing the surface directly into view. I say, directly; I mean indirectly into view with the aid of the rhinoscope. In cases of catarrh limited to the naso-pharyngeal space, attended with inflammation of the ear, it has been the customary practice to regard the disease as an affection of the ear, because the symptoms were not distressing until the hearing became impaired, and along with the beginning of this impairment in the hearing there was no pain in the ear. Pain, from what cause? From the swelling of the Eustachian tubes and limited supply of air in the tympanic cavity, and in that manner preventing the equal pressure of the air upon the drum membrane, giving rise to such tension as was sufficient to create great pain—great distress.

In some cases, where the quantity of air in the tympanic cavity from this source has been very limited, slight pressure upon the tragus forces the drum-head backward, and the joint between the malleus and incus is dislocated. This is an exceedingly painful condition, but may, if taken in time, be relieved, simply by inflating the middle ear with air. As to the treatment of catarrh, of course it would be impossible for anybody to exhaust the subject, or even approach exhaustion.

It is to the treatment of chronic catarrhal affections of the lining of the nose, throat and ear, that we propose to confine our remarks this evening. Cases attend with hypersecretion of mucus, partial loss of smell, dryness of the throat, the unpleasant sensation, if not positive pain, from attempts at swallowing, usually disclose upon inspection a double character of morbid change, a suppurative and proliferous inflammation, at the same time, in different parts of the same membrane; for instance, the lining of the inferior passages of the nose and the covering of the inferior turbinated bones yields an abundant secretion; perhaps the covering of the superior turbinated bones at the same time; but it frequently happens that the membrane covering the superior turbinated bones is perfectly dry, considerably swollen, very hard, and indurated. At the same time the posterior wall of the naso-pharyngeal space presents the appearance of induration and dryness, and whatever mucus manages to flow over upon the surface of this membrane speedily dries into a hard, tough crust. It may be seen simply by making an inhalation with the mouth open; it may be seen upon the entire posterior naso-pharyngeal wall, down into the bucco-pharyngeal space. Cases of this kind are seen in every-day practice.

The greatest discrimination is necessary in the treatment of this double form of disease, the suppurative and proliferous form coexisting in different parts of the same membrane. In the first place, wherever the disposition is found to discharge tenacious substances, it becomes necessary to aid nature by some sort of medicament which has power to dissolve the fibrinous matter, and in that way facilitate its expulsion. For this salines, such as are usually employed as gargles, are serviceable, applied directly to the naso-pharyngeal space, with what is know as the posterior nasal syringe, which is a curved instrument having a bulbous point, with a great number of perforations in the bulbous tip. With the aid of this, any of the salines usually employed as gargles may be thrown into the naso-pharyngeal space, and in that way brought into contact with the largest portion of the membrane, and wash out the offensive matter. Now, if mucus accumulates in a crypt, if it is found in a cavity in any part ot the body, it will rapidly degenerate into pus. The moment the requisite amount of moisture is withdrawn it dries. The dry quality is almost invariably due to the presence of pus. If it were not for pus, it would remain in the condition of ordinary mucus, and be expelled by being drawn up through the nose. Having cleansed the passages with a solution of bromide of potassium or muriate of ammonia—if the passage is very dry the bromide is not so good as the ammonia. Where these salts are not convenient, chloride of sodium may be used instead. It is not so good a defibrinizing agent, neither has it the power to stimulate secretion like the ammonia, nor has it the anæsthetic properties of bromide, yet it is a very good substitute in the absence of the other two salts. Of course all these things are to be kept in view in prescribing for cases of catarrh. I have taken this typical form of chronic catarrh as it presents itself for treatment, for obvious reasons.

After cleansing the passages with the posterior nasal syringe, which is an invaluable instrument, any instrument which has power to atomize or reduce fluid to the finest possible state of division may be used, and in that way you can medicate the whole of the nasal passages. Any instrument which has that power may be used for the purpose of medicating the naso-pharyngeal space and the little crypts in the nasal passages. I am in the habit of using, in preference to other instruments, what is known as "Holmes' Boston Perfumer." It has a metallic tip, and, if properly cleansed, will not get out of order for a long time. It is the most serviceable instrument that I know of for the purpose of medicating the passage after cleansing with the posterior nasal syringe. A solution of the bromide of potassium, as a general thing, is the best, say from ten to forty grains of the salt to an ounce of water, and in proportion to the strength of the solution, the interval should be great; if the forty-grain solution be preferred, it should not be used more frequently than twice in one day—once in twelve hours. If the weaker solution be preferred—and that should depend upon the quantity of secretion—if the secretion is going on rapidly, if there is a large amount of matter secreted, the weaker solution applied frequently is the preferable method.

Now, after the disease has lasted some time, and the discharge somewhat dried up, as it were, leaving still an inflamed surface—preter-naturally dry, without any disposition to throw off its secretion—a solution of iodine and glycerine answers the purpose best. That is to be used, also, with the atomizer; to be preceded by the posterior nasal syringe loaded with some sort of cleansing fluid, to remove any inflammatory matters collected in any of the crypts or cavities of the nasal passages, or anywhere in the naso-pharyngeal space.

By the use of the speculum, introduced into the interior nares, and a strong light reflected from a concave mirror, the nasal fossæ may be explored, except in those cases where there is great swelling in the covering of the superior turbinated bones. It is precisely in this locality that catarrhs are likely to linger, and likely, always, to escape observation; and when you think the patient is entirely relieved you find, to your surprise, that destruction of the bone has been going on—the superior turbinated bone perishing.

The iodine solution may vary from half a grain to five grains to the ounce; the five-grain solution being applicable to syphilitic subjects only. And there must always be a distinction between syphilitic ozæna and ordinary catarrh; the ordinary catarrh in the otherwise healthy subject never gives rise to any very offensive discharge. The decomposition of mucus may be very readily recognized by its odor, so may the destructive changes which take place in the osseous tissues, and in the other tissues of the body affected with syphilis, and what is known as strumous disease, which sometimes appears in the nose.

As a matter of observation, I have noticed that people who have catarrh are prone to tie a knot in the corner of the handkerchief, or roll it around the end of the little finger and poke it up the nose for the purpose of removing incrusted matter, and in that way they abrade the surface, which creates a greater disposition upon the part of the secretion to adhere to this part and become dry and inspissated, and so the attempt to remove is repeated, and what was originally an abrasion gets to be a complete destruction of the whole membrane, with exposure of the bone, and exposure is likely to be followed by death of the bone, and in that way loss of the septum of the nose frequently results in ordinary cases of catarrh. In cases of syphilitic disease of the nose, attended with loss of the septum, or a portion of it, there is always great tumefaction of the surrounding parts. The marginal outline is intensely red and considerably swollen, and this, with the offensive character of the discharge, distinguishes the syphilitic from the traumatic sores.

Another form, called dry catarrh, a proliferous inflammation with greatly diminished secretion, attacks persons given to excessive smoking. There is another form of catarrh which is attended, not by dryness nor by any great moisture, but by swelling of the nasal membrane, with loss of the sense of smell, which is common to persons given to the habit of snuffing. There is the smoker's catarrh, the snuffer's catarrh and epidemic catarrh.

In 1868, a German, by the name of William Dumeyer, who kept a grocery at Market and Fourteenth streets, had a sore throat, and I wished to examine his larynx with the laryngoscope, but the fauces were so very sensitive to the approach of the mirror that I was obliged to use a solution of bromide of potassium, which I had learned was an efficient local anæsthetic. I gave Mr. Dumeyer a twenty-grain solution of bromide of potassium, to be used as a gargle: that is the strength of the solution called the standard solution. It diminished the morbid sensibility of the fauces, and when I saw him again he said he did not need anything, he was well, and he wanted to settle his bill; he thought he was cured. I relate this to show you that the bromide destroys the sensibility of the membrane, and that suggested the application of it in the treatment of nasal catarrh. I formerly used this twenty-grain solution, which was regarded as the standard solution, for diminishing the morbid sensibility of the fauces, but I afterward got into the habit of using a much stronger solution, even to saturation. I now sometimes, but rarely, use the saturated solution. Experience has convinced me that the weaker solution is better for general use with the atomizer. In many cases the catarrh is attended with the disagreeable symptom of the continued presence of mucus lying upon the soft palate and manifesting a disposition to find its way down into the throat. That class of cases are most common, and they are very troublesome sometimes. They may be prolonged indefinitely by the use of too strong applications—by too harsh a plan of treatment.

It has been, unfortunately, the practice of too many physicians to introduce brushes and mops, with caustic solutions, and in that way perpetuate the disease. I believe that the only true plan for the relief of catarrhal affections, like all other localized diseases, is to search out the locality that is chiefly affected, and direct the topical application to that point. In the class of cases under my consideration, where there are general symptoms of distress depending upon the presence of too much mucus lying upon the soft palate, and manifesting a disposition to flow down into the throat, adhering to the uvula, a weak solution of bromide of potassium of five or ten grains is to be used. I employ what is known as Holmes' Boston Perfumer, held in such manner that the fluid will find its way into the naso-pharyngeal space; and then snuffing it up the nose and hawking it out clears the surface entirely. Having cleansed both nostrils in this way, and having cleared the naso-pharyngeal space, a decoction of ordinary green tea, or a solution of five grains each of carbolic acid and tannin to an ounce of water, or, as I generally prefer it, a mixture of equal parts of glycerine and water, is to be used immediately afterward, with the atomizer. This may be done three times every day; that is quite often enough. Cleanse the passages first with the bromide of potassium, which acts as a local anæsthetic, diminishing the morbid sensibility, and at the same time dissolving the fibrinous matter. Follow that with the decoction of green tea, or with the solution of carbolic acid and tannin. (A favorite prescription is this; half a drachm each of pure carbolic acid and tannin, to be dissolved in three ounces each of glycerine and water. That is a mixture that I am in the habit of prescribing every day.) It becomes necessary in many cases to make applications to the covering of the superior turbinated bones. These may consists of a half-drachm solution of carbolic acid to one ounce of water, or a half-drachm solution of iodine in glycerine, or a half-drachm solution of nitrate of silver to the ounce of water. These are the more common applications, and they are to be made with a brush or a little cotton-wool rolled upon the end of a probe, and the application is not to be repeated oftener than every other day. Catarrhal affections of the larynx generally call for local treatment. They are generally associated with bronchial catarrh, which requires, in addition to local treatment, some constitutional measures. In the chronic forms of naso-pharyngeal catarrh, constitutional measures are also required in a majority of instances. Where the affection invades the Eustachian tubes, creating an unpleasant noise in the ears that has been compared to the singing of grasshoppers, crickets, and steam escaping from a tea kettle, the application should be made to the ear itself, and should consist in simply filling the ear full of very warm water, and then have the head turned in a favorable position for the retention of the fluid, putting in a plug of cotton-wool to prevent the water escaping. Introduction of the Eustachian catheter may be practiced where there are evidently fluids accumulated in the tympanic cavity, or where the supply of air is deficient, and the patient cannot practice Valsalva's method, which consists in holding the mouth and nose shut, and blowing forcibly into the ears. There should be no fluids blown through the catheter in this class of cases, and the use of the catheter should be restricted to the actual necessities of the patient for the removal of fluids from the tympanic cavity on the introduction of air.—*Med. and Surg. Reporter.*

THE PHYSIOLOGICAL POSITION OF COPPER.

MR. EDWARD CLAPTON, in a letter to the *Lancet*, states that it is true that the systems of workers in copper may be saturated with the metal without any signs of interference with the health, but that this can hardly be considered the rule. A large proportion of them complain of habitual lassitude and giddiness, and a disinclination to go about when not at work, as other workmen do. Some of them are exceedingly thin and have unhealthy, sallow-looking complexions, and nearly all complain of more or less dyspepsia. It is a noticeable fact, however, that all kinds of wounds heal very rapidly in these men, though similar wounds in lead-workers are soon attended with suppuration and constitutional irritation. Mr. Clapton could not find that there had been a single instance known of cholera attacking these workmen, even in the worst epidemics; a similar immunity has been noticed in the copper foundries of Edinburgh and Paris. Copper, however, is not physiologically an astringent, for the workmen rarely suffer constipation, and diuresis is common among them. They also perspire rapidly, the perspiration having a greenish color. Dr. Pary has proved conclusively that the copper is absorbed into the system, and exists in the secretions as well in chemical combination with various tissues, such as even the hair and bones. He has also shown that copper is a constant component element of the body. The reason, then, of the comparatively slight injury from this metal in large proportions is doubtless because the system can tolerate an excess of what is a natural constituent infinitely better than it can the introduction of what is entirely foreign, such as lead, arsenic, and mercury. But this comparative immunity does not apply to those preparations in which its union with oxygen has been promoted by acid and fatty bodies, and especially by acetous fermentation. There is no danger in subsisting on cupriferous articles of diet, such as bread, beefsteak, etc., or in breathing for a time the air of a factory when it is highly charged with bright particles of the metal, or in taking sulphate of copper daily for a considerable time, but there is great danger in taking even very small quantities of verdigris or emerald green, or any preparation of copper which may be used to give a light-green color to "tinned peas" or any

other article of diet. With regard to the preserves which Dr. Hassall found impregnated with copper, it is well known that the large quantity of sugar which they contain renders them harmless, the experiments of Orfila and Duval having proved that sugar is a decided antidote to the poisonous action of copper. The same freedom from danger would not apply to vegetable acids or fatty substances in copper culinary utensils. Mr. Clapton had a patient at St. Thomas' Hospital, a sailor, who suffered fearfully from gastro-enteritis brought on by drinking lemon juice which had been kept in a copper tank. The rest of the crew suffered in a similar manner.

In France the action of copper has of late been the subject of frequent discussion in many of the societies. M. Laborde has found by experiment that if three or four grammes of sulphate of copper, thoroughly dissolved and filtered, be injected under the skin of a dog of medium size, it will cause death in from eighteen to twenty hours. The symptoms are a certain amount of pain at the points of injection, contraction of the pupils, paralysis of the hind-quarters, gradual acceleration of the pulse and respiration, and death in a sort of prostration. At the autopsy of one of these dogs, Mr. Laborde found congestion of the heart, lungs, liver, and kidneys; these organs were impregnated and infiltrated with dark, sepia-colored blood, that presented the characters of septicæmic blood. A contraction of the neck of the bladder had rendered the animal anuric; the urine contained a large quantity of copper, and also blood-globules and albumen. The gastric mucous membrane was very much inflamed and covered with a dark, bloody fluid.

In the discussion on M. Laborde's paper, in which the above case was detailed, in the *Société de Biologie*, M. Galippe denied that the salts of copper are really a poison, though he, of course, admitted their caustic action. He maintained that in the above case the death was due to the local lesion and not to a veritable copper intoxication, and, further, that it is impossible to poison a man with sulphate of copper without his knowledge. The taste of this and of other salts of copper is so detestable and so penetrating that if a drop of a solution of one and a half grains of this salt in a pint of water be placed on the tongue it will leave the most disagreeable taste. He called attention also to the fact that the proportion of copper found normally in the liver after a sudden death is much larger than when death has followed a lingering illness, and argued that as the normal figures are still unknown, it would be rash to fix on a maximum figure, above which would be considered proof of accidental or criminal poisoning. M. Rabuteau stated that two or three grains of bichloride of copper dissolved in ℥ xxij.–xxx. of water and injected under the skin of a frog caused paralysis of the muscles, especially of those of the hind legs, but that the properties of the sensitive and motor nerves are preserved; death follows in from half an hour to an hour.—*The Lancet and the Gazette Médicale of Paris.*

ON MILK DIET.

Dr. Tarnier, of Paris, recommends milk diet in obesity and albuminuria. In the latter disease he orders for the first day, one quart of milk with two portions of food; for the second day, two quarts of milk, and one portion of food; for the third day, three quarts of milk and one portion of food; for the fourth day and afterward, four quarts of milk and no food at all. In the treatment of obesity, it is not necessary to adhere so rigorously to the milk diet; a small quantity of ordinary food may be allowed. The patient may take the milk in such quantities and at such times as she likes, provided she takes the prescribed quantity *per diem*. The duration of the treatment will vary in different cases. If diarrhœa sets in, it is a sign that the treatment is not well borne. When the desired effect begins to show itself, it continues even after the treatment is suspended.

In the *Lancet*, Dr. George Johnson commends it most highly in chronic diarrhœa, dysentery, and acute Bright's disease. The chief stress is, however, laid upon the value of the method in acute and chronic cystitis; and one case of rapid and complete cure in a very severe case of two years' duration is reported.

The milk may be taken cold or tepid, and not more than a pint at a time, lest a large mass of curd, difficult of digestion, form and collect in the stomach. Some adults will take as much as a gallon in the twenty-four hours. With some persons the milk is found to agree better after it is boiled, and then taken either cold or tepid. If the milk be rich in cream, and if the cream disagree, causing heartburn, headache, diarrhœa, or other symptoms of dyspepsia, the cream may be partially removed by skimming. One reason, among others, for giving the milk, as a rule, unskimmed, is that constipation, which is one of the most frequent and troublesome results of an exclusively milk diet is, to some extent, obviated by the cream. As a rule, it is unnecessary to add bread or any other form of farinaceous food to the milk, which in itself contains all the elements required for nutrition. When the vesical irritation and catarrh have passed away and the urine has regained its natural character, solid food may be combined with the milk, and thus a gradual return may be made to the ordinary diet, while the effect upon the urine and bladder is carefully watched. There are some patients with whom, unfortunately, milk in any form, and even in small quantities, decidedly disagrees. Dr. Johnson suggests the employment of milk diet as a preparation for the operation of lithotomy, and states that he has seen two cases in which the vesical irritation and catarrh resulting from a stone in the bladder were much mitigated by the milk diet; the patients being thereby brought into a more favorable condition to undergo successfully, the one the operation of lithotomy, the other that of lithotrity.

A TURPENTINE BATH IN RHEUMATISM.

In a recent monograph, Dr. Bremond strongly advocates the use of turpentine baths, employed by placing the patient in an apparatus where his body is enveloped in an atmosphere saturated with turpentine.

The apparatus consists of a box placed in communication with a generator of steam, and it is so contrived that, at the moment when the steam enters, it is charged with turpentine, the latter being very finely divided into a kind of spray, which permits of its ready absorption by the skin.

The patient is seated on an easy chair inside the box, but his head is outside, and is never exposed to the medicated vapors. The temperature of the bath does not exceed forty-five degrees Centigrade, and generally forty degrees are sufficient; and Dr. Bremond states that he has observed only twice, out of more than 3,000 baths, any of that artificial exanthem which accompanies terebinthinate applications to the skin, and yet he employs for every bath more than 200 grammes (a gramme is about fifteen grains) of essence of turpentine, or rather of the essence of the California cedar, which seems to him more efficient than that of the indigenous turpentine. The medicated steam is spread over the surface of the body by means of the apparatus described, and is absorbed by the skin, and Dr. Bremond considers that the turpentine thus introduced into the tissues meets the residues of nutrition when these are in excess, and, by causing their combustion, prevents the undue formation of uric acid. He refers to another action of turpentine, namely, its effects on the tegumentary system, and he considers that the drug produces on the mucous membranes an effect quite as beneficial as that of its isomer copaiba.

REMOVING FOREIGN BODIES FROM THE EYE.

Prof. Dugas, of the Atlanta Medical College, says, in the New Orleans *Medical and Surgical Journal*:

It is extremely difficult for the surgeon, as well as painful to the patient, to dislodge the foreign body while the eye is instinctively avoiding every approach of the instrument. In order to surmount this difficulty, I have for many years been in the habit of placing my index finger upon the eye just within the canthus, and retaining it there until I have removed the object. The contact of the finger produces a sensation which, while not decidedly painful, is yet sufficiently decided to engross the attention of the patient, and to prevent his moving the eye at the approach of the instrument or on its contact with the ocular surface.

By this plan the foreign bodies may be removed from the surface of the eye as readily as from any other part, and without the risk of scratching or otherwise injuring the organ by repeated and unsuccessful attempts to take it by surprise, if I may use the expression, by sudden thrusts of the instruments used for the purpose. I am in the habit of using Scarpa's cataract needle, and find it better adapted to the purpose than any other instrument, whether the mote be imbedded or in simple contact.

IS CONSUMPTION INOCULATIVE?

Paris physicians and other savans are disputing whether consumption can be introduced into the human body by eating portions of animals whose lungs are diseased. Prof. Villemin and M. Chauveau take the affirmative, very positively, and declare that they have proved the fact on a large number of animals. On the contrary, Dr. Metzquer has appeared before the French Academy with an essay against the impossibility of such inoculation. The academy has considered the dispute of sufficient importance to warrant the appointment of a committee, which will at once thoroughly test the experiments which have in such inquiry been made upon various animals.

DEUTSCHE CHEMISCHE GESELLSCHAFT, BERLIN.

(June 11th, 1877.)

Prof. A. W. Hofmann, F.R.S., Vice-President, in the Chair.

Dr. R. Biedermann presented a communication on the "*Action of Phthalic Anhydride on Diamines.*" By melting the two substances together tolylene-diamine and phthalic anhydride yield $C_7H_6[N(CO)_2C_6H_4]_2$, melting at 104°, and $C_7H_6N_2H_2(CO)_2C_6H_4$, melting at 192°. These two phthalyl-tolylene-diamines result in all cases also when various dehydrating agents are used. The solubility of the first in alcohol, and of the other in acetic acid, permits an easy separation. Alkalies decompose the compounds into tolylene-diamine and phthalates. Perfectly analogous bodies are yielded also by the diamido-benzenes.

Dr. A. Pinner has found a "*Hexyl Chloral*, $C_6H_9Cl_3O$," among the by-products yielded in the preparation of croton chloral, boiling at 212°, and uniting neither with water nor CNH. It possesses no special action on the animal organism. Nitric acid changes it into trichloro-caproic acid, $C_6H_9Cl_3O_2$, insoluble in water, and reducible by zinc to a hexylenic acid, $C_6H_{10}O_2$, isomeric, if not identical, with the ethyl-crotonic acid of Frankland and Duppa. Allylene tetrachloride was found to be present in considerable quantities in crude croton chloral.

Dr. A. Pinner and Fr. Fuchs, "*Derivatives of Chloral*." Chloral-acetyl-cyanide, $CCl_3.CH(OC_2H_3O).CN$, was obtained by the action of acetic anhydride on chloral-cyanhydrate. This compound yields with H_2SO_4, acetyl-trichloro-lactamide; with aniline, dichloro-acetanilide; with acetate of aniline, mono-chlor acetanilide; with HN_3, dichlor-acetamide; and with ammonium acetate, dichlor-acetic ether. Chloral-cyan-hydrate itself gave with H_2SO_4 trichloro lactamide; with acetate of aniline, trichlor-ethyliden, diphenyl-diamine; and with urea, dichlor-acetyl-guanidine. Ammonium and chloral hydrate yield trichlor-ethylidene-imide, $CCl_3.CH:NH$, the first imide of the composition, X.CHNH as yet prepared.

The following communications have been received from non-resident members:

E. Linnemann, "*On Propylene.*" The author shows the inability of propylene to unite with H_2O at 100° and form propyl alchol.

"*Acrylic Acid.*" It is found that by melting sodium acrylate with alkalies hydrochloric acid and lactic acid are produced, the former yielding by decomposition acetic acid and formic acid.

A. Baeyer describes at length "*Oxy-phthalic Acid*, $C_8H_6O_5$." It is obtained in the form of the ether by the action of $NaNO_3$ on the ether of amido-phthalic acid. The acid itself crystallizes in colorless rosettes, melts at 180°, is easily soluble in boiling water and ordinary solvents, forms easily soluble salts, and changes into the anhydride on fusion. It resembles phthalic acid in general, and forms oxy-phthaleins with phenol, resorcin, etc., closely allied to the phthaleins. The position of the HO group has not been determined.

C. Böttinger, "*On Glyoxylic Acid.*" This acid yields on treatment with HCN glycollic acid and CO_2; and by means of Perkin's reaction with acetic anhydride and sodium acetate, oxalic and glycollic acids.

R. Fruhling and J. Schulz describe a "*New Method of Preparing Betain.*" $C_5H_{11}NO_2$, from the mother-liquor obtained in Scheibler's treatment of molasses. By the addition of a mixture of H_2SO_4 and alcohol, lime and potash are precipitated, while betain and the organic acids are dissolved in the alcohol. The separation of the betain from this solution is performed by means of a stream of HCl gas, and depends on the insolubility of the hydrochlorate in alcohol containing HCl. Pure betain is obtained by the action of Ag_2O on the aqueous solution of the hydrochlorate.

G. Lunge, "*Estimation of Nitrous and Nitric Acids.*" A series of comparative experiments tend to show that HNO_3 is determined more accurately by the method of oxidation with iron, and titration of the unoxidized residue with a solution of potassic permanganate, than by Siewert's method (reduction in alkaline solution with Zn and Fe). Titration with potassic permanganate is regarded as the only reliable process for determining nitrous acid. Hart's method with urea, with Crowder's modifications, as well as other methods, all failed to give as accurate results when tried on a solution of pure $AgNO_3$ in concentrated H_2SO_4. The determination of the two acids in the same solution is performed by first titrating the nitrous acid with permanganate, and then proceeding as above for the nitric acid.

H. Panisch has prepared "*Para-tolyl-phenyl-acetic Acid*, $(C_6H_4)(CH_3C_6H_4)CH.CO_2H$," by the action of toluen and zinc on phenyl-bromo-acetic acid, accompanied by small quantities of the ortho acid. Oxidation changes it into tolyl-phenyl ketone, and para-benzoyl-benzoic acid.

T. Zincke, "*Chlorides of Hydro-benzoin and Iso-hydro-benzoin.*" These two alcohols yield with PCl_5 and PCl_3 identical chlorides, $C_{14}H_{12}Cl_2$, hydro-benzoin, forming also a second isomer. All of these chlorides yield on regeneration of the alcohols iso-hydro-benzoin accompanied by but microscopic quantities of hydro benzoin.

C. Wachindorff and T. Zincke obtain "*Styrolen Alcohol* (*Phenyl-glycoll*), $C_6H_5.CHOH.CH_2OH$," by treating styrolen bromide with $AgNO_3$ or $C_2H_3O_2K$, and saponifying the ether formed. No isomer was observed. The alcohol crystallizes in needles, and is easily soluble in water. Several ethers have been prepared.

O. Jacobsen, "*Extraction of Xylens from Tar.*" By warming that portion of the crude xylols obtained from tar (which does not dissolve in ordinary sulphuric acid) with fuming acid, para-xylol is separated out in the form of the sulphonic acid, from which heating at 195° with HCl releases the hydrocarbon. The portion dissolved in ordinary sulphuric acid contains the meta and ortho-xylens. On addition of $NaCO_3$ the sodium salt ortho-xylen sulphonic acid crystallizes out, and leaving the meta-salt in the mother-liquor.

J. Thomsen, "*Heat of Solution of* Cl, Br, *and* I *Compounds.*" The author gives the tabular results of his experiments on eighty-six different bodies. The anhydrous compounds dissolve in water partially with absorption, and partially with development of heat. Tl_2Cl_2 and Al_2Cl_6 represent the two extremes. These compounds dissolving with development of heat form crystalline compounds with water. The hydrous salts show, with but few exceptions, an absorption of heat on solution. The heat of solution of the anhydrous salts increases with the atomic weight of the electro-negative components, and with the decreasing atomic weight of the electro-positive components, *i.e.*, is greater for I than Cl, for Mg than Ba. The same author shows that uniform laws hold good for the formation of ethers, and for the partial decomposition of salts in aqueous solutions by acids.

L. Brieger detects among the "*Volatile Constituents of Human Excrement*" acetic acid, butyric and isobutyric acids, phenol, indol, and a new substance—Skatol—allied to indol, and forming the chief portion of the aromatic fraction. Skatol is a white crystalline body, not so soluble as indol, and when injected beneath the skin enters as a coloring matter into the urine.

M. Nencki, "*On the Processes of Decay.*" By the distillation of old Roquefort cheese with sulphuric acid a volatile oil is obtained, to which the cheese owes its peculiar odor and taste. It is yellow, reacts neutral, and possesses a sharp burning taste.

L. Liebermann, "*On Nitro-benzoic Acids.*" In response to the late paper of Fittica on this subject, the author states that he has obtained an acid corresponding to Fittica's fourth isomeric nitro-benzoic acid, melting at 127°, by preparing the Ba salt of the nitration products of benzoic acid, decomposing with HCl the first portion of the salt which crystallizes out, changing this acid into a Ba salt, and repeating the process several times. After obtaining the acid melting at 127° the process was continued, and it was found to consist of a mixture of the three known nitro-benzoic acids. Further experiments were made on the melting-points of mixture of acids, which showed that they are always lower than that of the lowest melting acid in the mixture, if equivalent quantities are taken, and under all circumstances lower than the highest.

L. B. Hall and I. Remsen obtain a "*Para-sulphamic-mesitylic Acid*, $C_6H_2.(CH_3)_2.COOH.SO_2NH_2$," by the oxidation of mesitylen-sulphamide. The groups SO_2H and COOH are regarded as in the ortho position, on account of the impossibility of obtaining anortho-sulpho-benzoic acid from the ortho-toluolen sulphonic acid.

M. W. Iles and I. Remsen have examined the "*Oxidation Products of the Sulphonic Acids of Meta-xylol.*" Xylol-sulphamide melting at 110° yielded a sulphamine-meta-toluic acid, $C_6H_3SO_2NH_2CH_3.COOH$, regarded as possessing the position 1, 2, 4. The amide melting at 132° is decomposed entirely by oxidation.

E. Hart and I. Remsen have obtained "*Two Isomeric Sulphonic Acids from Para-nitro toluen*" by the action of fuming H_2SO_4, instead of the single one described by Beilstein and Kuhlberg. They are formed in about equal quantities, and are divided by the varied solubilities of the calcium salts.

F. Japp and G. Schultz has discovered "*Methyl-anthracen*, $C_{14}H_9CH_3$," in small quantities, accompanying anthracen and phenanthren in coal tar. Oxidation changed it into anthraquinon-carbonic acid, $C_{15}H_8O_4$.

"Velella Limbosa."—A. and G. De Negri.—Having studied the purple of the *Murex*, in which they have discovered indigotin and a red matter analogous to indigo-red, the authors had examined the blue coloring-matter of *Velella limbosa*, an oceanic mollusk, sometimes driven on shore by the winds. The coloring-matter is blue with a slight purple cast, very fugitive, fading rapidly with the death of the animal. It is insoluble in ether, chloroform, benzol, and bisulphide of carbon, but dissolves in water, and the solution becomes yellow on boiling. Acids turn it red; alkalies render it an amethystine rose, which acids do not re-convert to the original blue. It is bleached by chloride of lime and by oxygenated turpentine; acetone and essence of bitter almonds turn it red. Its spectrum has nothing remarkable, and it is at once distinguished from the purple of the *Murex* and the coloring-matter of *Aplisia* by the absence of absorption-bands.

OXYGEN AT HIGH PRESSURE.

M. P. BERT.

THE author has shown that oxygen at high pressure rapidly destroys all living beings and of all anatomical elements. All those phenomena known as fermentation, where the action depends on the presence of living beings, such as acetification, putrefaction, etc., are completely arrested even by the transitory action of compressed oxygen, whilst fermentations due to a dissolved matter (diastase, emulsine, etc.) perfectly resist the influence. He has applied this action of compressed oxygen as a means of physiological investigation. He finds that the ripening of fruits is arrested by exposure to compressed oxygen, and is hence due to a cellular evolution. The poison of the scorpion, whether liquid or dried and re-dissolved in water, entirely resists the action of compressed oxygen. Such poisons owe their action to chemical compounds comparable to the vegetable alkaloids. Fresh vaccine matter submitted for more than a week to oxygen at a pressure equal to about 50 atmospheres retained its virtue. The matter of glanders, after similar treatment, rapidly killed horses inoculated therewith. Hence these kinds of virus do not owe their properties to living beings or living cellules. Carbuncular blood, also, after exposure to compressed oxygen, though freed from bacteria, nevertheless retained all its dangerous properties.

DECOMPOSITION OF HYDROCHLORATE OF TRIMETHYLAMIN BY HEAT.

M. CAMILLE VINCENT.

THIS compound may serve for the easy and abundant preparation, not merely of mono-methylamin, but also of chloride of methyl, yielding hydrochlorate of ammonia as a by-product. This decomposition may be utilized for causing the chloride of methyl to react at a high temperature, and in the nascent state, upon various bodies, and especially upon aniline. If we heat a mixture of hydrochlorate of trimethlamin and hydrochlorate of aniline we obtain methyl-aniline, which distils over, and which only requires to be washed with water and rectified. If thus prepared it is free from all traces of aniline. The hydrochlorate of trimethylamin, which is now obtained on the large scale, may thus be judiciously utilized for the preparation of ammoniacal products and of pure chloride of methyl, which latter may serve either in the manufacture of methylated aniline colors, or in the preparation of pure methylic alcohol.

MANUFACTURE OF SULPHURIC ACID.

THE apparatus for the manufacture of concentrated sulphuric acid and other mineral acids, invented by Mr. L. Brumleu, of Berlin, consists mainly of a burner wherein brimstone or other sulphur-containing mineral is burned, of several vessels or chambers of any size or shape connected with the burner by means of pipes, and of an air pump or blower. The burner may be the same as used in the manufacture of sulphuric acid for the burning of brimstone or other minerals containing sulphur. At a suitable distance above the burning brimstone is a vessel of iron or other material, placed so that it is reached by the flame or heat of the burning material, and its contents become heated by the same. This vessel is filled with nitric acid or any other salts of nitre, with a due proportion of sulphuric acid, so that nitric acid is produced. At the side a small pipe of iron or other material is entered through the wall of the burner above the burning material, through which pipe a small stream of steam can be blown into the inside of the burner, just above the burning materials. From this burner, some distance above the burning brimstone, a pipe of a pretty large dimension is let through the back wall of the burner till within a short distance from the bottom of the first vessel or chamber, being passed through the top of this chamber. A damper is placed so that this tube can be closed inside the burner as occasion requires. The first vessel, or chamber, may be of any shape, the size being regulated in proportion to the quantity of sulphur to be burned and the size of the burner. By preference this chamber is constructed of brickwork, narrow, low, and long, for reason which will appear afterwards. It may be 12 to 20 ft. long, 4 to 5 ft. wide, and 2 ft. high, inside clear of the wall. The sole of the chamber must be of cast-iron plates, with a fireplace under it to heat the contents of the chamber. According to the nature of the acid to be made, the inside of this chamber must be lined with lead as far as up to the doors, or it may remain free from any lining, so that the sides and top are coated with cement and the sole of iron. This chamber is divided in different compartments by either glass plates or iron plates, according to requirement, cased in sheet lead, these divisions reaching only from the top of the chamber to about its middle, leaving the lower half of the chamber undivided. Each of these divided compartments is on one side provided with an opening so arranged that it can easily be closed by a sliding door of glass or otherwise. These slides or shutters must have a small hole just barely large enough to pass the handle of a rake through for the purpose of stirring up or raking the contents of the chamber without opening the doors. Besides the pipe or tube connecting the chamber with the burner there is another pipe carried through the top of the chamber to within a few inches of the sole of the chamber; this pipe is connected with an apparatus where air is heated in any way it may suit best, and also provided with a damper. This first chamber is connected with a second chamber of about the same dimension and size by a pipe coming out from the top of the first chamber, going through the top of the second chamber to within a short distance from the sole or bottom of the same. This chamber is also divided into several compartments, with this difference, that the partitions of the second chamber go from top to bottom, forming thereby several separated compartments, all connected through pipes going from the upper part of the first partition to within a short distance of the sole or bottom of the next, and so forth from the second to the third, and so on to the last compartment. This second chamber must be placed so much higher than the first one as to permit its liquid contents to run through the intermediate compartments into the first chamber. For this purpose all the chambers or compartments are connected by pipes of lead, glass, or any other suitable material, and these pipes are provided with cocks, so that they can be opened or shut as the case may require; these pipes going from the bottom of one partition to the bottom of the next one, the contents of all the partitions can be run into the first chamber. These small compartments require no lining, but only a coating of cement: openings or doors are not absolutely required, but may be useful for the purpose of inspecting the chamber and for repairs, and have to be so arranged that they can be luted air-tight. From the top of the last compartment a pipe connects the whole chamber system with an air pump, blower, or other instrument suitable for sucking the air from the chamber.

When the apparatus is thus arranged it is ready for use. If it is to be employed for making sulphuric acid the chambers are kept dry and empty—that is no water is put in. The brimstone in the burner is then ignited, and when it is fairly burning and nitric acid provided in the vessel for that purpose, the blower is put in motion and the steam pipe is opened to let in a stream of steam. By the suction of the blower the sulphurous acid, the steam, and the nitric acid vapor will be drawn through the tube into the first chamber, and there, the chamber being kept cold, condensing drop down in a liquid form as sulphuric acid. To assist this dropping down and regulate the speed of passage through the whole chamber system half partitions are constructed as described. In the first chamber the strongest acid is produced, whereas the mostly exhausted vapors in passing the smaller chambers have only a very weak acid in small quantities, and finally pass out through the blower completely exhausted. During this stage of the process the cocks of the connecting pipes are kept open, so that all the weak acid which is precipitated in the compartments may run back into the first chamber.

The velocity and size of the blower or air pump must be regulated so that all the sulphurous acid, steam, etc., is drawn from the burner into the chamber. If the pump is too small or is worked too slowly sulphurous acid will escape through the door or air-holes of the burner, if too large or worked too quickly the draught will be too quick, and the vapors hurried too quickly through the chambers and not able to discharge all the sulphuric acid which is contained in them. The quantity of steam can be regulated in such a way that the acid in the chamber is about 40° Baumé strong, to avoid useless condensing afterwards. When in this way the first chamber is filled about half or up to the door, or as high as the lining of lead will admit, the act of concentrating begins and is continued till the acid has acquired strength of 66° Baumé or more. To obtain this object fire is made under the first chamber, the tube connected with the burner closed, and instead of that the tube connected with the hot-air furnace opened, and the cocks of the pipe closed which connects the different chambers. The blower or air-pump now put in motion draws the hot air quite through the weak and hot acid, and in so doing dissolves water and some acid in its passage, which is carried off with the air through all the small chambers, where, these being kept cold, the weak acid will be condensed and collect at the bottom of the chamber. The passing of hot air through the hot acid will not alone be the means of concentrating the acid by the passage of the air through the acid; it will be kept in a state of motion just as is produced by the boiling of a liquid, and a strong evaporation of water and acid takes place, which by the draught of the blower is drawn into the small cold chambers and there condensed. As soon as the required strength is obtained the acid may be drawn off by a syphon or a pipe left for this purpose in the chamber into a cooling vessel, or left in the apparatus to cool there, just as it may be convenient. To keep up a perpetual process each burner ought to connect with two sets of chambers, so that one makes weak acid during the same time that the other concentrates.

In applying the invention to the manufacture of chloride of lime or bleaching powder, the required ingredients are brought into the first chamber, and the process carried on the same way as for making sulphuric acid; the sulphuric acid formed then will, being condensed, drop down on the ingredients, decompose them, and make the chlor gas free, which in passing through the chambers will there deposit the moisture which it contained, and may then by the air pump or blower be conveyed through pipes to the rooms where lime is spread out to take the gas up and form bleaching powders. In the beginning of the process no fire is required until the contents of the chambers are nearly decomposed, when heat has to be applied to forward the process, and drive off all the gas by fire under the chamber as well as by the influx of hot air. When all the salts are decomposed the influx of sulphuric acid from the burner has to be stopped, and the fire as well as the influx of hot air continued till all or nearly all the chlor gas is driven off. During all the time the contents of the chamber have to be stirred up and raked up by means of iron rakes, the handles of which are passed through the small holes left for this purpose in the doors. Of course the doors have to be made tight as much as possible, and luted to prevent the escape of gas and the entering of cold air.

To decompose salt for the purpose of getting the sulphate of soda and hydrochloric acid, the first chamber is filled with salt, and the small chamber with water up to the door of the chamber, and then the process is carried on as for making sulphuric acid. The water in the small chambers will take up the gas which is created by the decomposition of the salt, and form thereby hydrochloric acid, whereas the salt is turned into sulphate soda. When all, or nearly all, the salt is decomposed fire is made under the chamber, and even with the assistance of hot air the whole mass is raked and stirred up by the rakes till all the gas is driven off just as is always done now in making this article. For works where much carbonic acid is used for the purpose of making bicarbonate of soda, the last chamber may be provided with a stirrer or agitator, and then filled with water and chalk or marble dust, the stirrer being kept in motion, and the gas being drawn through the chalk will be decomposed to muriate of lime, while carbonic acid getting free may be forced by the blower into the room where soda is arranged in the usual way to be transformed into bicarbonate of soda.

PRODUCTION OF ALUMINIUM.

LEAD or a sulphide of lead, or mixture of the two, are according to the invention of Mr. E. A. Wilde, of Notting Hill, melted, and in a melted condition are poured upon dried or burnt alum. The crucible in which they are contained is then placed in a furnace, and heated together with suitable fluxes. The metal when poured out of the crucible will be found to be mixed with aluminium. The aluminium and lead can either be subsequently separated the one from the other by any known means, or the alloy or mixture of the metals can be employed for various useful purposes for which pure lead is more or less unsuited.

MM. A. GUILLEMARE and F. Lecourt have experimented successfully with cholorophyle as a substitute for the salts of copper in giving a green color to peas, beans, cucumbers, and other canned or pickled vegetables. The color thus obtained is said to be more natural than that which is given by copper, the vegetables are more wholesome, and the flavor is better on account of the absence of all astringent or metallic taste.—*Comptes Rendus.*

SPECTRUM OF THE ELECTRIC SPARK IN A COMPRESSED GAS.

M. A. CAZIN.

THE electric spark in a gas is analogous to the ordinary flame of a hydrocarbon. In each of these luminous sources there are gaseous particles which produce a spectrum of lines, and solid or liquid particles which produce a continuous spectrum. These are derived in case of the spark from the electrodes and the sides of the vessel when very near. When the pressure is increased these particles are more abundant, their continuous spectrum becomes more brilliant, and, finally, causes the disappearance of the linear spectrum of the gaseous particles. It is in the flash of fire that things take place thus: the paler luminous halo or aureola is formed of gaseous particles whose linear spectrum is more or less visible; it is to the entire spark what the blue base of the flame of a candle is to the entire flame. At ordinary pressures, in nitrogen, the spark is pale and furrowed with small flashes of fire. We see in the spectroscope the grooves ascribed to nitrogen, and in their intervals the characteristic lines of this gas. On compressing we see the grooves disappear little by little, whilst the continuous ground of the spectrum becomes more brilliant. When the pressure exceeds two atmospheres there are only six lines of nitrogen from the orange to the blue, and five diffused bands beyond. At 10 atmospheres there only remain the two nitrogen lines $\lambda = 567$ and $\lambda' = 500$, and then a very brilliant line in the violet $\lambda'' = 424$, which first appears at 5 atmospheres. The sodium line is very distinct, whilst it is not to be distinguished at ordinary pressures. About 15 atmospheres the spark becomes dazzling; upon the continuous spectrum are seen the four lines above mentioned, and certain brilliant points due to platinum. In air compressed above 30 atmospheres the spark produces intense reddish vapors, and the spectrum showed the absorption spectrum of hyponitric acid.

THE JABLOCHKOFF ELECTRIC CANDLE.

A SECOND series of experiments illustrating the lighting capabilities of this important invention took place on June 15th last, at the West India Docks, London, in the presence of a large body of scientific gentlemen and others interested in this last addition to our illuminating appliances. On this occasion everything worked smoothly, and taking the experiments as a whole they were eminently satisfactory. The electric power was produced by one of the Paris *Alliance* Company's magneto-electric machines, with thirty-two horse shoe magnets of seven plates each, and worked by a small agricultural engine of about eight horse-power.

The trials commenced about 9 o'clock with the lighting up of the yard. Four lamps, mounted on posts about 15 feet high, were used, each of which were said to be equal to one hundred gas lights, but the size of the gas light was not specified. The lights were toned done by opal glass globes, which seemed somewhat too thick for the purpose, the light given out by the candles being, if anything, a little too subdued. The very slight flickering, of which we have already spoken, was much less apparent than on the occasion of the first trial—an improvement which was no doubt due to the engine being in better working order. It seems that a great deal depends on the motive power working regularly; for after the lamps had been burning for about five minutes the light suddenly improved, becoming much more steady and brilliant. After burning for about twenty minutes the lights were extinguished, and four gas lamps, with four powerful burners to each, were turned on, evidently with the intention of showing the difference between the orange color of the gas flame and the pure white of the electric lamp. The company then adjourned to a large warehouse at the top of the adjacent building, measuring about 50 yards long by 25 yards wide, which was lighted from the outside by three electric candles without any intervening globes. Two of these candles were placed at the side and one at the end, but being only breast high the shadows of persons passing in front of them greatly interfered with the experiments tried. One of the objects of this portion of the trial was to ascertain whether this light could be used for sampling various descriptions of produce and merchandise. Several experts were present, but owing to the position of the light being horizontal instead of vertical there seemed to be some doubt as to its value in the case of samples of coffee, grain, pepper, and similar commodities, inasmuch as the strong shadow cast horizontally by the individual grains of the produce under examination interfered materially with their color—the particular tint of a coffee berry, for instance, being an important factor in the estimation of the value of a sample. It was far otherwise with a number of samples of colored alpaca goods. The most difficult colors to judge of by gas light, or during foggy weather, are dark olive greens, puces, and blues. Next to these come the lightest shades of straw yellow and cream color. In the first case the colors are not to be distinguished from black, and in the second from white; but under the electric light the darkest navy blues and the lightest greys came out in their tints, even to the eyes of the uninitiated. The company then adjourned to the quay below, alongside which a large barque had been moored. Here the practicability of lighting ships' decks and holds, and the adjoining wharfs, was most satisfactorily demonstrated, as well as the portability of the light itself.

The amount of heat given off by M. Jablochkoff's candle is comparatively small, the glass globe of one of the lanterns used for lighting up the ship having been found to be only just comfortably warm after having been lighted for twenty minutes.

The last experiment tried was, scientifically speaking, the most interesting of the whole, demonstrating as it did that M. Jablochkoff has succeeded in entirely doing away with the necessity for using carbons for the electric light. His newest form of candle consists of a thin plate of his kaolin composition, about 1¼ inches long by 1 inch broad, and about $\frac{1}{16}$th inch thick. The sides of the plate are inserted in grooves cut in the wires forming the electrodes of the battery, which project very slightly above the top of the plate. In order to light this new form of candle a bridge of ordinary graphite is carried along the top edge of the porcelain plate. The graphite gradually disappears, and the melted portion of the porcelain becomes incandescent, gradually vaporizing at the rate of a millimetre an hour. The light given out by the porcelain seems softer, mellower, and much more constant and steady, than that given off by the combination of carbon and porcelain; indeed, after five minutes' examination with black spectacles, we failed to discern anything more than a barely perceptible start at distant intervals.

Altogether, MM. Jablochkoff and Denayrouze may be congratulated on the success which attended their very interesting series of trials on Friday night.—*Chemical News.*

LESSONS IN MECHANICAL DRAWING.

By Professor C. W. MacCord.

Second Series.—No. XII.

On the Screw Propeller. (Continued.)

We have thus far regarded the screw propeller as made of a certain number of blades, each being a portion of a true helicoidal surface, without thickness. This constitutes the acting face, which is perfectly capable of exact delineation, and by confining our attention to it alone, the problem of drawing the screw has been much simplified. But the blade must have sensible thickness in order to be of any practical use, as well as an acting surface of proper form; and, having mastered the processes of representing the latter, we are prepared to consider the results of adding the former.

Probably the simplest case is that in which the blade is supposed to be made of uniform thickness: an idea of which may be obtained by the aid of the illustration before used—that is, by imagining a sheet of metal to be wound edgewise round the hub. It must, however, be noted that, as the screw surface, being warped, is incapable of development into a plane, a sheet of metal of uniform thickness cannot be actually thus wound into a screw-thread of uniform thickness; in employing that illustration, the material was supposed to be capable of whatever compression, extension, or distortion might occur in the process of winding it; and that the plate which was uniformly thick before bending will not be so after it. Probably, within practical limits, this discrepancy would not be great enough to prevent our using the same form for bending the second plate; but, if it be thought otherwise, the back of the first one may be used as a pattern for a new mould, a new form cast, and the plate bent upon it, then it certainly ought to fit. At any rate, difficult or not, it has been done; one of the lightest and most beautiful propellers ever made in this country, or in any other, for that matter, having been constructed by Captain Ericsson substantially as here described, the double thickness near the center being riveted to a projection on the the wrought iron hub, accurately planed to the required shape.

Now, in making a blade in this manner, we would naturally wish to know of what size and shape to cut the sheet at first, in order that when bent it shall have the desired outline. This can only be determined approximately, as above stated, because the warped surface cannot be developed into a plane, the case being similar to that of making a map on a flat sheet of paper which shall accurately represent a part of the double-curved surface of the globe, or to that of laying out the sheets of metal to cover a dome. But a method of approximation, sufficiently close for practical purposes, is illustrated in Fig. 75, in which *I* is an end view, and *II* a side view, of a portion of a helicoidal surface, bounded by two planes, $a'a'$, $e'e'$, perpendicular to the axis *C D*. The surface is for this illustration supposed to be continued till

Now draw another horizontal plane, *P P*, and find as before the curve $o''r''s''$. In *I V*, take *p* as a center, and with a radius equal to the length of the curve $o''r''$ describe an arc; then with *m* as a center, and a radius equal to *m r* in the end view, describe another arc cutting the first one in *r*. Set off *m n* equal to the length of the curve $m''n''$, and about *n*, with radius *m s* in the end view, describe an arc, intersected at *s* by another about center *r*, with radius equal to the length of the curve $r''s''$. About *r* describe an arc with radius *C r* in the end view, and about *c* another with radius $o'b''$ in the top view, intersecting at *b*; with center *s* and radius *C s*, describe an arc, cut at *A* by another whose center is *b* and radius $b''a''$.

Now, when the plate is twisted, we see that *o m*, *o p*, *p r*, and *m r* are by this construction each long enough to fill their proper places on the screw surface; the points *o* and *p* do not change their places; *m* is carried backward in the horizontal plane *L L* until *o m* is formed into the curve $o''m'$, by which means, *m r* retaining its length, *r* is raised up to its proper level, being at the same time carried backward by the bending of *p r*. Nevertheless, the surface *p o m r* on the blade being twisted, the plane surface *p o m r* cannot be fitted to it without distortion; of which the amount may be quite small in those portions nearest the lines *c c* and *o n*, especially if the transverse planes determining the elements, and the horizontal ones determining the curves, made use of in the construction, are close together, but it will rapidly increase as we recede from those lines.

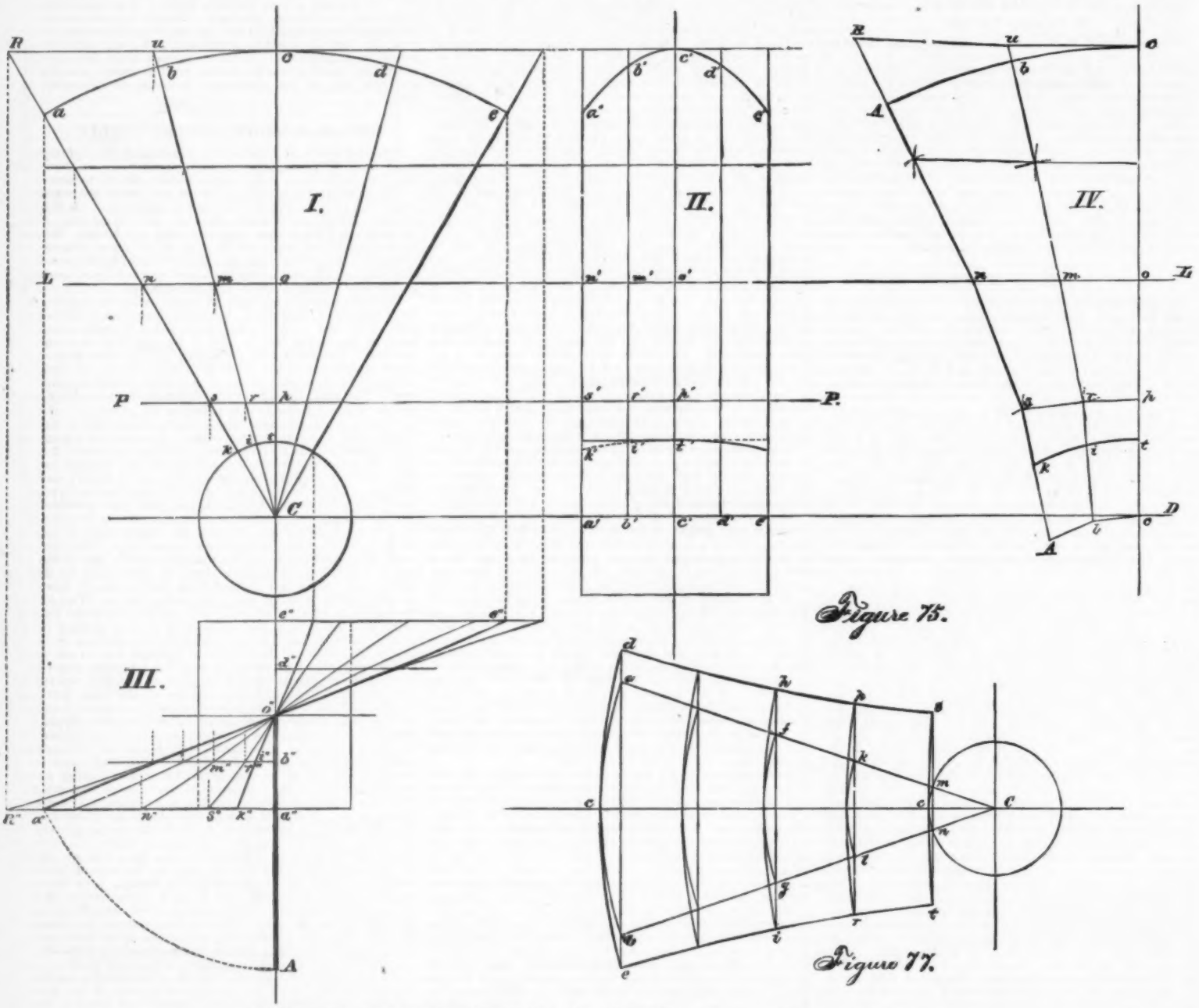


Figure 75.

Figure 77.

LESSONS IN MECHANICAL DRAWING. Second Series. No. 12.

with that understanding the comparison was well enough, because within the limits by which the screw blade is usually bounded, the distortion would not be very great. We shall presently show how to find its amount approximately; in the meantime we may remark that in actual practice the difficulty of making a blade of sheet metal is not as great as it may appear. If a true helicoidal surface be "struck up" in the manner described in the last lesson but one, and a heavy casting made upon it, this may be used as a form, to which an iron plate may be bent by hammering while hot with wooden mallets; we shall then have the acting face of our blade correct.

Without going into detail, it will be obvious that, if this plate be of the right thickness at the rim and for a certain distance within it, it will not be thick enough near the hub, since in the latter region it has to bear all the strain, and the pressure on the outer part acts with a great leverage. We may therefore place behind the first plate another, thus doubling the thickness for the necessary distance from the hub, and rivet the two together. Now, the discrepancy between the front and the back of the first plate will be that due to the distortion above mentioned, the effect of which will be it meets the axis, so that in *I* the elements appear as complete radii, *Ca*, *Cb*, etc., the one marked *Ce* being vertical; externally it is limited by a cylinder as usual. Let *LL* be a horizontal plane; it cuts the elements in the points *o*, *m*, *n*, in the end view, seen at o', m', n', in the side view, and in the top view, *III*, at o'', m'', n'': through the latter points a curve is drawn, which is the section of the surface by the plane *LL*.

Now we may suppose our blade to be formed from a plane passing vertically through the axis, and therefore containing the element $c'c'$, by twisting one corner in one direction and the other in the opposite, which is indicated in the top view, the double line $A\,o''$ representing the edge of one half of the sheet before the twisting, during which process *A* goes to a''. We may also suppose that the curve $o''\,m''\,n''$, which is horizontal, is formed by the mere bending of a horizontal right line on this plane; while the vertical element remains unchanged in length and position. Therefore, in constructing our approximate development, *I V*, we proceed thus: Draw the vertical element, *c c*, and through *o* a horizontal line, on which set off *o m* equal to the length of the curve $o''\,m''$ in the top view.

Still, within the limits assigned in practice, the construction will answer for ascertaining the size and nearly the form of the plate, although it is probable that in any case the blade will require to be trimmed to the exact outline after bending, as it is very unlikely that the distortion would take place in precisely the same manner in every instance.

The process above described is of course to be repeated by drawing other horizontal planes above *L L*; in the figure we have shown one, *R R*, tangent to the outer cylinder, the elements being produced to pierce it. If the planes are taken very close together, the broken lines *p r s*, *b r b*, *A s A*, in *I V*, will ultimately become curves, approximately representing the lines which after bending will become the elements and curves similarly lettered in *I*, *I I*, and *I I I*. The curves of the rim, and the junction with the hub, are determined by setting off in *I V*, *R A* equal to *R a* in *I*, *u b* equal to *u b*, etc., for the former; and *p t*, *r i*, *s k*, equal to the corresponding distances in *I*, for the latter. This diagram, Fig. 75, is made without any regard to practical proportions, for the purpose of making the illustration of the method used as clear as possible, and for the same reason but few elements and intersecting planes are employed.

In Fig. 76 we show an application to a practical case, in laying out a sheet for the blade of a propeller, which has been made, though not in this manner. In regard to the selection of the point *o*, it is to be observed that, as the part of the plate near the rim is twisted more from its original plane form than the part near the hub, this point should not be at the centre of the element *c c*, but rather nearer its outer end; and the element *c c* itself, about which the twisting is supposed to take place, should be so chosen that the distortion may be as nearly as possible equally distributed on each side of it, so that in the case of an overhanging blade like the one here shown, the inner end, *c*, of this element is nearer to *d* than to *e*, *d a* being the overhanging, which in this case is also the trailing, edge.

In this example, a closer approximation has been made by the use of a greater number of radii and intersecting planes, the surface being thus subdivided into smaller superficial elements, and intermediate radii were employed for finding the forms of the edges *A D* and *B E*, which is done in a manner precisely similar to that explained for finding the forms of the outer and inner edges, *A B* and *D E*.

Nothing has been said of the manner of finding the lengths of the curves cut from the screw surface by the intersecting planes. Nor do we deem it worth while to say anything more than this, that if the operator's conscience compels him to go through any ceremony of rectifying these intersections, he will be likely to get a sufficiently accurate result if he considers each portion in its turn as an arc of a circle, whose center and radius he finds by trial and error.

Even this, however, we consider wholly a waste of time, for in the first place the curvature within the practical limits of the problem is very slight, so that the difference between the arc and the chord will be hardly perceptible; and, in the second place, the problem itself is impossible, and the whole construction makes no pretensions to do anything more than give a safe and a reasonably close approximation to the required form and size.

We mention this latter circumstance the more particularly because we do not wish this attempt at an approximate development of an undevelopable surface to be confounded by anybody with a certain fanciful figure, which, as some one has set the senseless fashion of drawing it, may be met with by some of our readers. And for the sake of putting them on their guard against it, we give the construction referred to, though for perfectly obvious reasons we do not attempt to explain it.

In Fig. 77, *a b n m* is the end view of a blade, the central element *c c* being horizontal. The chord *a b* is produced, until its length, *d e*, is equal to the actual or developed length of the helical arc represented by *a c b*, and a curve, presumably elliptical, though a circular arc would practically coincide with it, is drawn through *d*, *c*, and *e*; and this for some unknown reason is called the development of the helical arc, which it misrepresents.

Any number of other arcs, as *f g*, *k l*, are then drawn about *C*, and their chords similarly treated; and as a finishing touch, the curves *d h p s*, *e i r t*, are drawn through the extremities of these extended chords. And the figure thus outlined is solemnly called the development of the screw blade; whereas, in point of fact, it neither is anything nor represents anything, but is utterly without meaning or utility of any kind or degree.

Now, although our sheet when bent into shape will not be of absolutely uniform thickness, yet the variations will not be great; which is fortunate, as it would be practically impossible to find exactly what they are. The propeller, whose blade is shown in Fig. 76, has a diameter of six and a half feet, the pitch being eleven and a half; such a blade might be made of a plate of iron three quarters of an inch thick, backed by another of the same thickness extending two thirds of the way from the hub to the rim; and a mere inspection of the diagram will suffice to show that the distortion of the original sheet, as there laid out, will be so small, that in making a representation of the complete screw the effect upon the thickness may be disregarded. That is to say, we may draw it as though the thickness were uniform, without introducing any appreciable error, although we order it to be made as above described; and it is hardly necessary to add that such a drawing we ought, at any rate, to be able to make, since we might choose to order a brass screw to be cast, whose blade should be of one uniform thickness in one part, of another in another part, as here proposed, and thus we return to the problem as at first stated.

Before attempting to make this drawing, it is well to have a clear understanding of the terms used. In regard to these, it must be noted that, in speaking of the thickness of the blade, we mean the thickness measured in a direction normal to the helicoidal surface. And normal means exactly what is very often called *perpendicular* to the surface, an expression perfectly correct when the surface is a plane. The other word is, however, preferable, as being applicable with equal propriety to all surfaces, and it is defined thus: If a plane be tangent to any surface, the line perpendicular to that plane at the point of tangency is normal to the surface.

This being understood, it will be seen that a screw-thread of uniform thickness is a thing which as yet we have not met with. Many labor under the impression that the thread of a square-threaded screw is uniformly thick, which is by no means the case. It is true that the variation, within the ordinary practical proportions of such screws, is quite small, and this is probably the cause of the erroneous idea that there is none at all.

Perhaps the fact that the thickness, measured in a direction parallel to the axis, *is* uniform, has led some to think that it would be so if measured normally to the surface. But a little consideration of the circumstance that the helices on the outer and inner cylinders, having the same pitch, are of different obliquities, will show the fallacy of this conclusion.

If we develop the helices bounding a thread on the outer cylinder, and also the corresponding ones on the inner, we shall find that the perpendicular distances between the two pairs are not equal: neither of them is the true measure of the normal thickness of the thread, at the points on the helices corresponding to those where the perpendiculars cut the developments; still they will not differ greatly in length from the actual thicknesses, and the illustration will have served its purpose if it aids any in eradicating an error.

Obviously, in order to measure the normal thickness, we must first be able to determine the direction of the normal. We may as well explain here as anywhere else the general principle upon which this determination depends. If on any surface we draw two intersecting lines, and at the point of intersection draw a right line tangent to each of these, the plane of these two tangents will be tangent to the surface at this point; and a line perpendicular to them at the same point will be perpendicular to the plane, and therefore normal to the surface.

Figure 76.

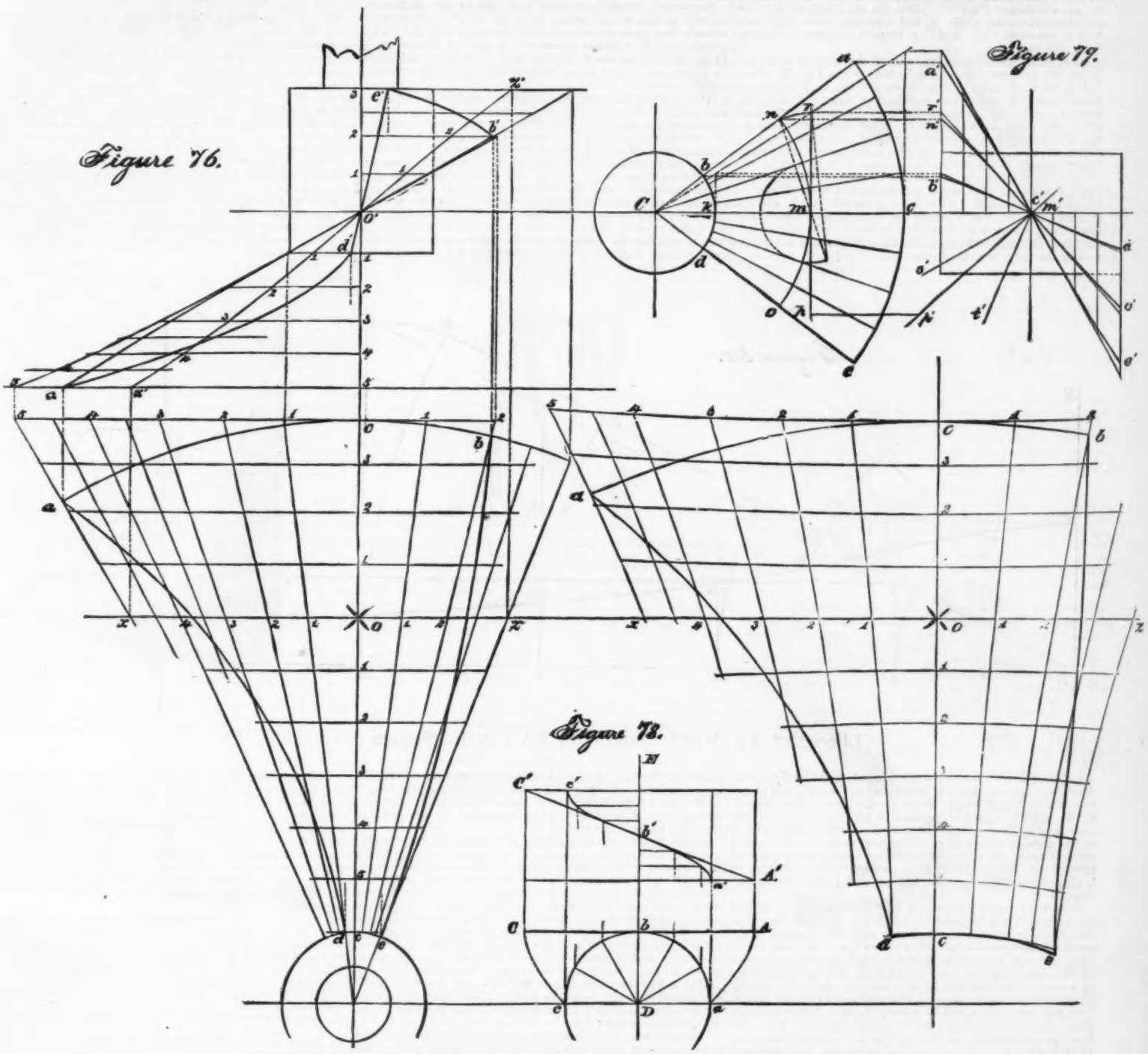


Figure 77.

Figure 78.

LESSONS IN MECHANICAL DRAWING. SECOND SERIES. No. 12.

If one of the lines drawn on the surface be straight, its tangent will coincide with it; and in the helicoid we have at once one line of the tangent plane, by drawing an element through the point at which we wish to draw the normal. We can also draw a helix through the point, which will lie on the surface; now, if we can draw a tangent to this helix, we shall have determined the tangent plane, since this tangent intersects the element already drawn. This can be readily done by availing ourselves of the fact that the helix also lies on the surface of a cylinder, and as we have already seen the cylinder can be developed on its tangent plane, on which the helix appears as a right line.

Thus, in Fig. 78, $D E$ is the axis of the cylinder, on the upper half of which is drawn a part of a helix, seen as $a\ b\ c$ in the end view, and $a'\ b'\ c'$ in the top view. Now let the cylinder be cut along the right and left hand elements, and its upper half developed into the plane $A\ C$, tangent to the cylinder along the upper element, and therefore coinciding in direction with the curved surface at its highest part. The helix develops into the right line, $A'\ C'$, which, therefore, has the point b', and that point only, in common with the helix; since the latter is formed by winding the plane back on the cylinder, and the direction of the plane is not changed in that winding at the central line, the direction of $A'\ C'$ is not changed at the point b', and therefore this right line, seen in the other view as $A\ C$, is tangent in space to the helix at this point.

Now, then, we can manage to draw the normal to the helicoid, the process of doing which is shown in Fig. 79, where $C\ D$ is the axis, and $a\ b\ d\ e$ represents in the usual manner a screw blade, the other view showing the inner and outer helices, $a'\ c'\ e$, $b'\ c'\ d'$. Suppose that we wish to draw the normal at the point m, which, lying on the horizontal element, $C\ e$, will appear in the other view as m', coinciding with c', as this element is in that view perpendicular to the paper. Draw through m the arc $o\ n$ with center C; it is at once the projection of a helix on the surface of the screw blade, seen in the other view as $n'\ m'\ o'$, and the base of the cylinder on which that helix lies. At m draw a tangent to $o\ n$, and on it rectify the arc $m\ n$, which gives $m\ r$; project r to r', and draw $r'\ m'$, which will be tangent to the curve $n'\ m'\ o'$ at m'; and the line represented by the two projections $m\ r$, $m'\ r'$, will be the tangent to the helix.

The intersection is a helix; now we must be able to draw on the same cylinder the line in which it is cut by a surface whose normal distance from the helicoid is everywhere the same. This line will also be a helix; for, if we consider any element of the helicoid, it will be seen that there must be one normal of the given length, whose outer extremity will lie on the surface of the given cylinder, always supposing the latter to be large enough; and this extremity being rigidly connected with that element, moves according to the same law—that is, it both rotates and advances uniformly. Now go one step further, and draw a series of normals of equal length, at different points of the same rectilinear element, whose motion, according to the above law, generates the helicoid; then the line joining the outer extremities of these normals will, being invariably connected with the element, at the same time generate the required surface, at a constant normal distance from the helicoid. This surface will partake of the helicoidal nature, inasmuch as it is composed of helical elements.

It is not, however, a *warped* surface, for it contains no right lines, as we shall find that the moving line, or generatrix, whose points describe the helices composing the surface, to be itself curved.

Before we get through with this subject, we shall meet with propellers whose acting faces are of a similar nature, being in fact generated in precisely the same way, only with generatrices of different curvature; so that the construction of this one will be serviceable by way of practice, aside from its immediate utility as an auxiliary in the problem under consideration.

The mode of determining this curved generatrix, as above explained, is shown in Fig. 80, in which $A\ B\ C$ represents a portion of a helicoid, of which C is the axis; corresponding to one half of an ordinary screw blade, the element $C\ A$ being horizontal, and therefore appearing in the side view merely as a point, E. Let the pitch be such that, in revolving through the angle $A\ C\ B$, this element shall advance along the axis through the distance $E\ F$; then $C\ B$ will appear in the side view as a part of $F\ G$, perpendicular to $C\ E$. At A draw the tangent to the arc $A\ B$, which, rectified, will be equal to $A\ D$; project D to G, draw the right line $G\ E$, which will be the tangent to the helix described by the point A, and $E\ M$ perpendicular to $G\ E$ is normal to the helicoid at the same point, which normal must appear in the end view in the direction $A\ D$; therefore, assume the length $E\ M$, which is the thickness of the proposed blade, and projecting M to P, we have $A\ P$, the normal at A, as seen in the end view of the screw.

Since all the normals are to be of the same length, describe about E through M a quadrant, terminated by the vertical and horizontal center lines. Now, the helicoid ultimately coincides with the axis, because the rectilinear generatrix travels along in contact with it; therefore the normal, at the extremity C of the element $A\ C$, will appear in the side view as $E\ L$, in the end view as $C\ N$, both perpendicular to $C\ E$. And if the helicoid be extended so that $C\ A$ becomes infinite, the curvature and the obliquity of the outer helix will disappear; which may also be seen from another point of view—thus, the longer we make $C\ B$, and consequently $A\ D$, the less will be the angle $G\ E\ S$ in the side view, until ultimately $G\ E$ will coincide with $S\ E$, and the infinitely remote normal will be $E\ U$, perpendicular to $E\ S$, and therefore coincident with $C\ E$.

The quadrant $S\ U$, then, contains the outer extremities of all the normals to the helicoid that can be drawn through the element $C\ A$, if produced to infinity, as seen in the side view. As seen in the end view, we have found that $E\ L$ is represented by $C\ N$, and $E\ M$ by $A\ P$; consequently the arc $L\ M$ must there be represented by some line passing through the points N and P.

For the purpose of illustration, we have divided $C\ A$ into equal parts at 1, 2, 3; through these points arcs are drawn about C, to cut $C\ B$, which are rectified upon their tangents, giving the perpendiculars 1-1, 2-2, 3-3, the upper extremities of which are projected to the points 1, 2, 3, on $F\ G$. The right lines, $E\ 1$, $E\ 2$, $E\ 3$, then, are tangents to the helices represented by these arcs, and the radii perpendicular to these lines are the normals, whose outer extremities, I, $I\ I$, $I\ I\ I$, are projected back to I, $I\ I$, $I\ I\ I$ on the verticals, 1-1, 2-2, 3-3, just as M was to P on $A\ D$. The end view of the line, $L\ M$, then, must pass through the points thus found. If intermediate points be required, they may be determined in a similar manner; but in some cases greater precision may be attained by another construction, which we also illustrate. In the first place, it is to be observed that, since the arcs intercepted by $C\ A$ and $C\ B$ are proportional to their radii, the upper extremities of the verticals, 1-1, 2-2, 3-3, in the end view, must lie in the same straight line, $C\ D$, whence the distances, $F1$, $F2$, etc., are proportional to the distances, $C1$, $C2$, etc., measured either on $C\ D$, which in the side view appears as $F\ G$, or on $C\ A$, which appears there as the point E. Consequently, $F\ G$ may be considered as the projection of an inclined right line, upon which the extremities, 1, 2, 3, of the tangents, $E\ 1$, $E\ 2$, $E\ 3$, lie. This being so, any line parallel to $F\ G$ may be considered as the projection of an inclined line, which, if it cuts the axis and one of these tangents, will also intersect the others. Since the normals are respectively perpendicular to the tangents, and lie in the same planes, parallel to the paper in the side view, a similar argument applies to them—that is to say, any line perpendicular to $F\ G$ may be considered as the projection of an inclined right line, which, if it cuts two of the normals, will cut them all. Thus, let $K\ M$, perpendicular to $F\ G$, cut the lowest normal, $E\ L$ in K, and pass through the extremity, M, of the highest one; it will then intersect the others, and, as seen by the similarity of the correspondingly shaded triangles, the distances, $K\ 1$, $K\ 2$, etc., are proportional to the distances, $F\ 1$, $F\ 2$.

To illustrate the application, bisect $C\ 1$ at d, and let it be required to find the point on $N\ P$, which lies on the perpendicular, $d\ e$. In the side view, we may either bisect $V\ I$ at i, and draw $E\ i\ b$, or produce $E\ I$ indefinitely, draw $H\ O$ perpendicular to $E\ S$, bisect $H\ O$ at a, and draw $E\ a$, to determine b, which, being projected back to $d\ e$, gives e the required point.

We have, then, the line which, being rigidly connected with the element $C\ A$ and moving with it, will generate a surface whose normal distance from the original helicoid is everywhere equal to $E\ L$. Suppose now that we wish to draw the intersection of both surfaces with a cylinder having the same axis, and radius $C\ v$. The base of that cylinder is the circle through v about C; and W must therefore be the projection of the point in which this cylinder cuts the curved generatrix $N\ P$, in the end view; which projected to the quadrant $L\ U$ gives Z, the projection of the same point in the side view.

We know that the trace of the original helicoid on the cylinder will be a helix, the visible arc in the end view being $v\ x$, and projecting x to $F\ G$, we have u, one point in the side view, E being another. Bisect $v\ x$ in s, $F\ b$ in r, draw $r\ y$ perpendicular to $C\ E$, project s to y, which will be another point; so also s is obtained by bisecting $v s$ in t, $r\ E$ in j, and proceeding as before; and in like manner for other points if needed.

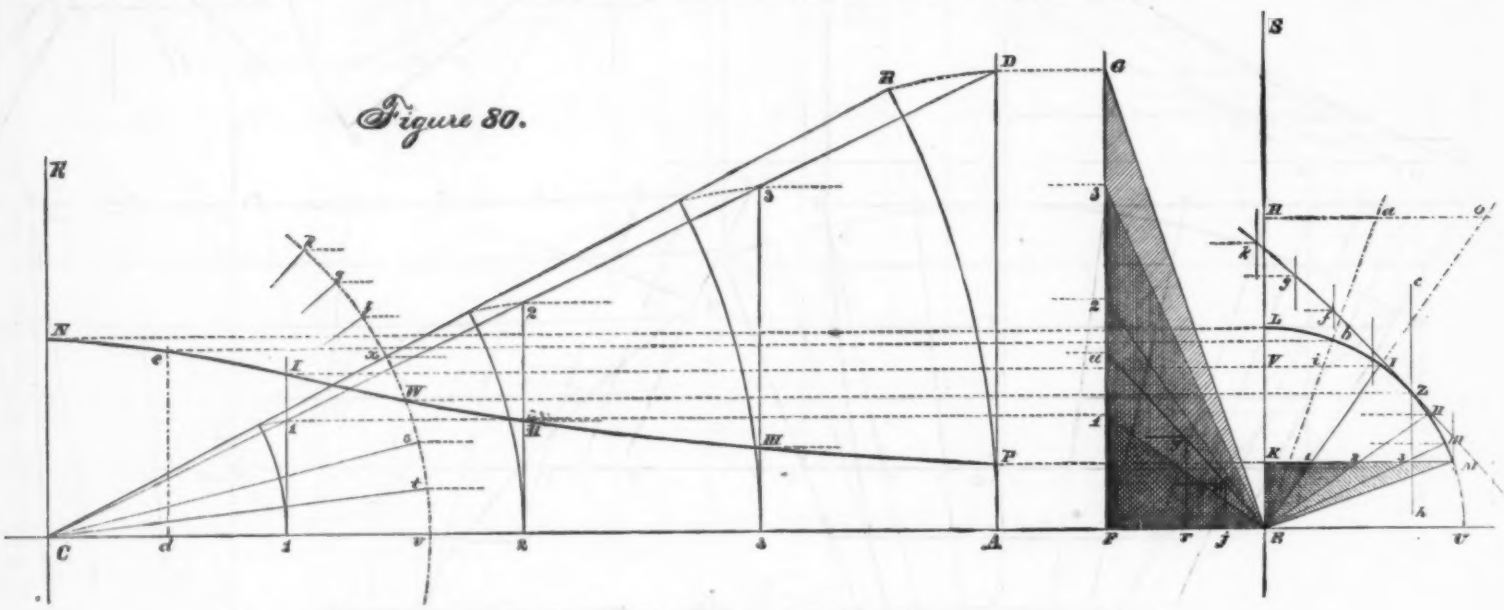


Figure 80.

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In the end view, $m\ r$ is also the plane tangent to the cylinder, seen edgewise, since it is parallel to the axis, and therefore perpendicular to the paper in this view. The tangent to the helix is therefore parallel to the paper in the side view, and is there seen in its true direction; it intersects at m' the element which is perpendicular to the paper in that view, whence the plane of those two lines is seen edgewise there as $r'\ m'$, consequently $p'\ m'$ perpendicular to $r'\ m'$ at m' is also perpendicular to this element, and normal to the surface.

If now we repeat this process with the outer helix, we find the normal at the extremity e, to take, in the side view, the direction $s'\ m'$; if we use the inner helix, the normal at the point k will appear in the side view as $t'\ m'$. By thus drawing a series of normals to the screw blade, at different points of the same element, it is clear that we shall have elements of a new surface, normal to the helicoid; and it is equally clear, from a consideration of the positions of these normals, that this new surface will be a warped one. Were there any particular object in doing so, we might inquire a little further into the nature of this surface; at present, however, there is none, for although we shall presently have occasion to make use of it, we shall be able to accomplish our objects by determining, in the manner above described, as many of its elements as we may find necessary.

We remarked above that, if the helices, say on the outer cylinder of a square-threaded screw be developed, the perpendicular distance between them will not be the true measure of the normal thickness of the thread; which will now be clear, even had it before seemed obscure or incorrect, in view of the fact that the normal to the screw surface lies in a plane tangent to the cylinder on which the helix is drawn; whereas the perpendicular referred to will, when the development is restored, be on the surface of that cylinder, itself becoming a helix. If the cylinder be large, and the thickness of the thread small, the difference will not perhaps be appreciable; but if those conditions be reversed, it will become quite conspicuous. And in drawing the propeller, we encounter both cases; for example, in the screw constructed in the foregoing manner, we have at the rim a thin blade, whose edge is on a large cylinder; while at the hub the cylinder is small, and not only is the blade of double thickness, but behind both plates comes the still thicker projection on the hub itself, to which they are riveted.

Hence, in order to make the drawing accurately, one more preliminary problem must be mastered. We know that when the helicoid is cut by a cylinder having the same axis, also a helix of the same pitch, whence the best mode of constructing it is to make use of the subdivisions already laid off; for instance, by making $W\ f$ equal to $x\ s$, then drawing a vertical through Z, as $c\ h$, and a parallel to this at a distance from it equal to $E\ r$, and projecting f in the end view to f on this parallel in the side view. Other points, g, k, being spaced on the circle at distances equal to $s\ t$, and parallels to $c\ h$ whose distances from the one last drawn and from each other are equal to $E\ j$, we obtain additional points, $g\ k$, in the side view of the required helix.

This line, it is to be understood, is merely an auxiliary; it is, in short, a necessary tool to do a certain piece of work with, that work being the drawing of a propeller blade, certain portions of which are of one thickness, others of another, but uniform in each case; and with that we shall proceed in our next lesson.

The curve traced on the cylinder by the point W or Z is

HOW TO DRAW A STRAIGHT LINE.*

By A. B. Kempe, B.A.

The great geometrician Euclid, before demonstrating to us the various propositions contained in his "Elements of Geometry," requires that we should be able to effect certain processes. These *Postulates*, as the requirements are termed, may roughly be said to demand that we should be able to describe straight lines and circles. And so great is the veneration that is paid to this master-geometrician, that there are many who would refuse the designation of "geometrical" to a demonstration which requires any other construction than can be effected by straight lines and circles. Hence many problems—such as, for example, the trisection of an angle—which can readily be effected by employing other simple means, are said to have no geometrical solutions, since they cannot be solved by straight lines and circles only.

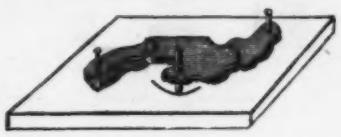
It becomes then interesting to inquire how we can effect these preliminary requirements, how we can describe these circles and these straight lines, with as much accuracy as the physical circumstances of the problems will admit of.

As regards the circle we encounter no difficulty. Taking Euclid's definition, and assuming, as of course we must, that our surface on which we wish to describe the circle is a

* Lecture at South Kensington, England, in connection with the Loan Collection of Scientific Apparatus.

plane, we see that we have only to make our tracing-point preserve a distance from the given center of the circle constant and equal to the required radius. This can readily be effected by taking a flat piece of any form, such as the piece of cardboard I have here, and passing a pivot which is fixed to the given surface at the given center through a hole in the piece, and a tracer or pencil through another hole in it, whose distance from the first is equal to the given radius; we shall then, by moving the pencil, be able, even with this rude apparatus, to describe a circle with considerable accuracy and ease; and when we come to employ very small holes and pivots, or even larger ones turned with all that marvellous truth which the lathe affords, we shall get a result unequalled perhaps among mechanical apparatus for the smoothness and accuracy of its movement. The apparatus I have just described is of course nothing but a simple form of a pair of compasses, and it is usual to say that the third Postulate postulates the compasses.

Fig. 1.



But the straight line, how are we going to describe that? Euclid defines it as "lying evenly between its extreme points." This does not help us much. Our text-books says that the first and second Postulates postulate a ruler. But surely that is begging the question. If we are to draw a line with a ruler, the ruler must itself have a straight edge; and how are we going to make the edge straight? We come back to our starting-point.

Now I wish you to understand the difference between the method I just now employed for describing a circle, and the ruler method of describing a straight line. If I apply the ruler method to the description of a circle I should take a circular lamina, such as a penny, and trace my circle by passing the pencil round the edge, and I should have the same difficulty that I had with the straight edge, for I should first have to make the lamina itself circular. But the other method I employed involves no begging the question. I do not first assume that I have a circle and then use it to trace one, but simply require that the distance betwen two points shall be invariable. I am of course aware that we do employ circles in our simple compass, the pivot and the hole of the moving piece which it fits are such; but they are used not because they are curves we want to describe (they are not so, but are of a different size) as is the case with the straight-edge, but because, through the impossibility of constructing pivots or holes of no finite dimension, we are forced to adopt the best substitute we can for making one point in the moving piece remain at the same spot. If we employ a small pivot and hole, though they be not truly circular, the error in the description of a circle of moderate dimensions will be practically infinitesimal, not perhaps varying beyond the width of the thinnest line which the tracer can be made to describe; and even when we employ large pivots and holes we shall get results as accurate, because those pivots and holes may be made by the employment of very small ones in the machine which makes them.

It appears, then, that although we have an easy and accurate method of describing a circle, we have at first sight no corresponding means of describing a straight line; and there would seem to be a substantial difficulty in producing what mathematicians call the simplest curve, so that the the question how to get over that difficulty becomes one of a decided theoretical interest.

Nor is the interest theoretical only, for the question is one of direct importance to the practical mechanician. In a large number of machines and scientific apparatus it is requisite that some point or points should move accurately in a straight line with as little friction as possible. If the ruler principle is adopted, and the point is kept in its path by guides, we have, besides the initial difficulty of making the

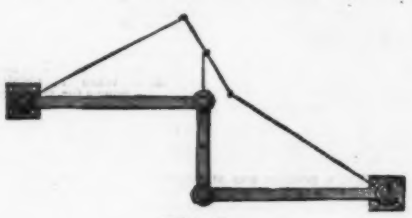


Fig. 2.

guides truly straight, the wear and tear produced by the friction of the sliding surfaces, and the deformation produced by changes of temperature and varying strains. It becomes therefore of real consequence to obtain, if possible, some method which shall not involve these objectionable features, but possess the accuracy and ease of movement which characterises our circle-producing apparatus.

Turning to that apparatus we notice that all that is requisite to draw with accuracy a circle of any given radius is to have the distance between the pivot and the tracer properly determined, and if I pivot a second "piece" to the fixed surface at a second point having a tracer as the first piece has, by properly determining the distance between the second tracer and pivot I can describe a second circle whose radius bears any proportion I please to that of the first circle. Now, removing the tracers, let me pivot a third to these two *radial* pieces, as I may call them, at the points where the tracers were, and let me fix a tracer at any point on this third or *traversing* piece. You will at once see that if the radial piece were big enough the tracer would describe circles or portions of circles on *them*, though they are in motion, with the same ease and accuracy as in the case of the simple circle-drawing apparatus; the tracer will not however describe a circle on the *fixed* surface but a complicated curve.

This curve will, however, be described with all the ease and accuracy of movement with which the circles were described, and if I wish to reproduce in a second apparatus the curves which I produce with this, I have only to get the distances between the pivots and tracers accurately the same in both cases, and the curves will also be accurately the same. I could of course go on adding fresh pieces *ad libitum*, and I should get points on the structure produced, describing in general very complicated curves, but with the same result as to accuracy and smoothness, *the reproduction of any particular curve depending solely on the correct determination of a certain definite number of distances.*

These systems, built up of pieces pointed or pivoted together, and turning about pivots attached to a fixed base, so that the various points on the pieces all describe definite curves, I shall term "link motions," the pieces being termed "links." As, however, it sometimes facilitates the consideration of the properties of these structures to regard them apart from the base to which they are pivoted, the word "linkage" is employed to denote any combination of pieces pivoted together. When such a combination is pivoted in any way to a fixed base, the motion of points on it not being necessarily confined to fixed paths, the link structure is called a "linkwork:" a "linkwork" in which the motion of every point is in some definite path being, as before stated, termed a "link-motion." I shall only add to these expressions two more: the point of a link-motion which describes any curve is called a "graph," the curve being called a "gram."

The consideration of the various properties of these "linkages" has occupied much attention of late years among mathematicians, and is a subject of much complexity and difficulty. With the purely mathematical side of the question I do not, however, propose to deal to-day, as we shall have quite enough to do if we confine attention to the practical results which mathematicians have obtained, and which I believe only mathematicians could have obtained. That these results are valuable cannot, I think, be doubted, though it may well be that their great beauty has led some to attribute to them an importance which they do not really possess; and it may be that fifty years ago they would have had a value which, through the great improvements that modern mechanicians have effected in the production of true planes, rulers and other exact mechanical structures, cannot now be ascribed to them. But linkages have not at present, I think, been sufficiently put before the mechanician to enable them to say what value should really be set upon them.

The practical results obtained by the use of linkages are but few in number, and are closely connected with the problem of "straight-line motion," having in fact been discovered during the investigation of that problem, and I shall be naturally led to consider them if I make "straight-line

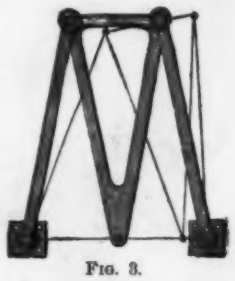


Fig. 3.

motion" the backbone of my lecture. Before, however, plunging into the midst of these linkages it will be useful to know how we can practically construct such models as we require; and here is one of the great advantages of our subject—we can get our results visibly before us so very easily. Pins for fixed pivots, cards for links, string or cotton for other pivots, and a dining room table, or a drawing board if the former be thought objectionable, for a fixed base, are all we require. If something more artistic be preferred, the plan adopted in the models exhibited by me in the Loan Collection can be employed. The models were constructed by my brother, Mr. H. R. Kempe, in the following way. The bases are thin deal boards painted black; the links are neatly shaped out of thick cardboard (it is hard work making them, you have to sharpen your knife about every ten minutes, as the cardboard turns the edge very rapidly); the pivots are little rivets made of catgut, the heads being formed by pressing the face of a heated steel chisel on the ends of the gut after it is passed through the links; this gives a very firm and smoothly working joint. More durable links may be made of tin-plate; the pivot-holes must in this case be punched, and the eyelets used by bootmakers for laced boots employed as pivots; you can get the proper tools at a trifling expense at any large tool shop.

Now, as I have said, the curves described by the various points on these link-motions are in general very complex. But they are not necessarily so. By properly choosing the distances at our disposal we can make them very simple. But can we go to the fullest extent of simplicity and get a point on one of them moving accurately in a straight line? That is what we are going to investigate.

To solve the problem with our single link is clearly impossible: all the points on it describe circles. We must therefore go to the next simple case—our three-link motion. In this case you will see that we have at our disposal the distance between the fixed pivots, the distances between the pivots on the radial links, the distance between the pivots on the traversing link, and the distances of the tracer from those pivots; in all six different distances. Can we choose those distances so that our tracing-point shall move in a straight line?

The first person who investigated this was that great man James Watt. "Watt's Parallel Motion," invented in 1784, is well known to every engineer, and is employed in nearly every beam-engine. The apparatus reduced to its simplest form is shown in Fig. 2.

The radial bars are of equal length—I employ the word "length" for brevity, to denote the distance between the pivots—the links, of course, may be of any length or shape, —and the distance between the pivots or traversing link is such that when the radial bars are parallel the line joining those pivots is perpendicular to the radial bars. The tracing-point is situate half-way between the pivots on the traversing piece. The curve described by the tracer is, if the apparatus does not deviate much from its mean position, approximately a straight line. The reason of this is that the circles described by the extremities of the radial bars have their concavities turned in opposite directions, and the tracer, being half-way between, describes a curve which is concave neither one way nor the other, and is therefore a straight line. The curve is not, however, accurately straight, for if I allow the tracer to describe the whole path it is capable of describing, it will, when it gets some distance from its mean position, deviate considerably from the straight line, and will be found to describe a figure 8, the portions at the crossing being nearly straight. We know that they are not quite straight, because it is impossible to have such a curve partly straight and partly curved.

For many purposes the straight line described by Watt's apparatus is sufficiently accurate, but if we require an exact one it will, of course, not do, and we must try again. Now it is capable of proof that it is impossible to solve the problem with three moving links; closer approximations to the truth than that given by Watt can be obtained, but still not actual truth.

I have here some examples of these closer approximations. The first of these, shown in Fig. 3, is due to Richard Roberts of Manchester.

The radial bars are of equal length, the distance between the fixed pivots is twice that of the pivots on the traversing piece, and the tracer is situate on the traversing piece, at a

Fig. 4.

distance from the pivots on it equal to the lengths of the radial bars. The tracer in consequence coincides with the straight line joining the fixed pivots at those pivots and half-way between them. It does not, however, coincide at any other point, but deviates very slightly between the fixed pivots. The path described by the tracer, when it passes the pivots, altogether deviates from the straight line.

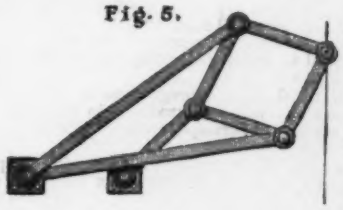
The other apparatus was invented by Prof. Tchebicheff of St. Petersburg. It is shown in Fig. 4. The radial bars are equal in length, being each in my little model five inches long. The distance between the fixed pivots must then be four inches, and the distance between the pivots or the traversing bar two inches. The tracer is taken half-way between these last. If now we draw a straight line—I had forgotten that we cannot do that yet, well, if we draw a straight line, popularly so called—through the tracer in its mean position as shown in the figure, parallel to that forming the fixed pivots, it will be found that the tracer will coincide with that line at the points where verticals through the fixed pivots cut it as well as at the mean position, but, as in the case of Roberts' parallel motion, it coincides nowhere else, though its deviation is very small as long as it remains between the verticals.

We have failed then with three links, and we must go on to the next case, a five-link motion—for you will observe that we must have an odd number of links if we want an apparatus describing definite curves. Can we solve the problem with five? Well, we can, but this was not the first accurate parallel motion discovered, and we must give the first inventor his due (although he did not find the simplest way), and proceed in strict chronological order.

In 1864, eighty years after Watt's discovery, the problem was first solved by M. Peaucellier, an officer of Engineers in the French army. His discovery was not at first estimated at its true value, fell almost into oblivion, and was rediscovered by a Russian student named Lipkin, who got a substantial reward from the Russian Government for his supposed originality. However, M. Peaucellier's merit has at last been recognized, and he has been awarded the great mechanical prize of the Institute of France, the "Prix Montyon."

M. Peaucellier's apparatus is shown in Fig. 5. It has, as you see, seven pieces or links. There are first of all two

Fig. 5.



long links of equal length. These are both pivoted at the same fixed point; their other extremities are pivoted to opposite angles of a rhombus composed of four equal shorter links. The portion of the apparatus I have thus far described, considered apart from the fixed base, is a linkage termed a "Peaucellier cell." We then take an *extra* link, and pivot it to a fixed point whose distance from the first fixed point, that to which the cell is pivoted, is the same as the length of the extra link; the other end of the extra link is then pivoted to one of the free angles of the rhombus; the other free angle of the rhombus has a pencil at its pivot. That pencil will accurately describe a straight line

(*To be continued.*)

OUR HAY CROP.

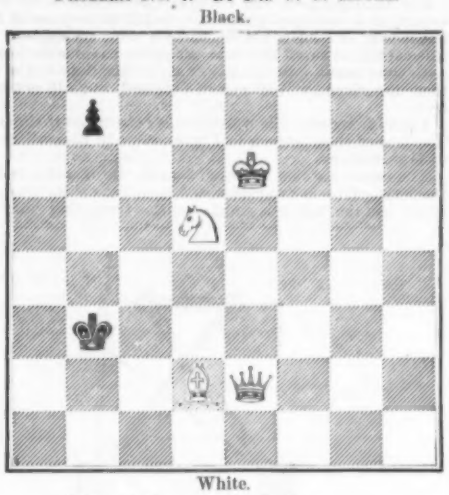
As the farmers throughout this section are now harvesting this all-important product, the following facts concerning the national crop of 1875 may be of interest in showing its relative position as regards other crops. Hay was third on the list of farm products of the United States in respect to the value of the crop. In round numbers there were 44,000,000 acres sown in Indian corn, 26,000,000 in wheat, and 23,000,000 in grass for hay. The values of the products for the same year are set down as follows: Indian corn, $555,445,930; hay, $342,203,445; wheat, $294,580,990; cotton, $272,936,400; oats, $129,499,930; potatoes, $65,019,420; tobacco, $30,342,600; barley, $29,952,082; rye, $13,631,900; buckwheat, $7,166,267. Wheat, cotton, and tobacco all yield in pecuniary value and importance to hay, which, in 1876, was worth nearly twenty per cent. of the value of all the products of the United States.

SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department, may be addressed to SAMUEL LOYD, Elizabeth, N. J.]

PROBLEM No. 1.—BY DR. C. C. MOORE.

Black.



White.

White to play and mate in three moves.

By Dr. C. C. Moore.

Mates in three moves.

AN apology is not required for the introduction in the pages of this Journal of a department devoted to a game which has been termed the essence of ingenuity and science; whose origin dates with that of the earliest arts, and which has been the recreation—if not the school—of the greatest intellects.

Among its votaries we find not only the names of famous warriors, statesmen, and philosophers, but the great master-minds that revolutionized the world of arts and science.

Fulton was passionately fond of the game, Franklin wrote essays upon the subject, and many of our players yet testify to the skill of Howe and Morse.

Among a large circle of chess friends in both this and other countries, I find many names recognized as the leading inventors of the day; and I have, therefore, assumed charge of this department with a certainty of receiving a warm welcome from old friends, and of presenting a subject that will possess a peculiar interest to a large majority of the readers of the SCIENTIFIC AMERICAN.

Time and circumstances will influence me in the selection of subjects, but, as I depend largely upon the genius and assistance of my friends to make it attractive, I take this early opportunity of refering to my future programme.

I propose not only to give portraits and biographical sketches of our leading problemists and players, but also the finest specimens of their skill.

Selections from all of the famous problem tournaments, with full information in regard to them.

The decisive (or best) games from celebrated matches, carefully annotated, with complete scores, dates, etc.

Of course I shall give the current events of the day, but prefer not to put on record mere off-hand games played between amateurs. Every game must possess some historical value, as the result of a match between clubs or celebrated players, and I especially invite the assistance of our readers in gathering information, and selecting the finest games.

The same plan will be pursued in future in regard to publishing problems. I wish to give the public such positions as have already become famous on account of extraordinary merit, and to give specimens of the styles of leading composers; but contributors must bear in mind that I hope they will furnish such as are fully up to their best standard, and, if agreeable, add some little information in regard to number of compositions, and which are their best works.

The usual popular programme of solution tournays and time records will be introduced in due season, as well as such answers to correspondents as refer to subjects possessing general interest.

Solutions will be given four weeks after the publication of the problems, and a general index furnished at the end of the year to carry out the idea of a complete Chess Encyclopedia.

S. L.

INTERNATIONAL CHESS CONGRESS.

The French chess players are now making most active preparations for arranging a grand international tournament to take place during the next year's World's Exhibition, to be held at Paris. Our players are also waking up to a sense of the situation, and are determined that we shall be duly represented.

BLACKBURNE vs. ZUKERTORT.

The contest between the above-named celebrated masters of the game of chess was commenced on Wednesday, the 27th ultimo. The time is limited to fifteen moves per hour, and the stake £30 a side. The first game, in which Mr. Blackburne, as second player, adopted the French defence, was won by him after a struggle of three and a half hours' duration. The second game, a Ruy Lopez, lasted four hours, and was scored by Mr. Zukertort.

This second game we present to our readers this week, with notes by Mr. Steinitz. We regret to learn that, after so many delays and adjournments, that the match has again been abandoned. It is proposed that it shall be resumed in the fall, and as both players are eager for the fray we may be agreeably disappointed to learn at any moment that play will be recommenced; but knowing how difficult it is to get such celebrated magnates together again, we have but little faith in the so-called adjournment.

BACK NUMBERS.

WE can supply any desired back numbers of the SUPPLEMENT from its beginning—10 cents per copy. To be had at this office and of newsdealers throughout the country.

A NEW CHESS ASSOCIATION.

A convention of the chess fraternity took place at the Café International on the evening of the 19th of July.

A new chess association was formed, to be known as "The American Chess and Problem Association." Mr Eugene B. Cook was elected President; J. G. Beldon and J. G. White, Vice Presidents; J. B. McKim, Secretary; Dr. C. C. Moore, Treasurer; and a general committee, consisting of the chess editors throughout the United States.

The executive committee representing the different sections of the country, as follows:

Joseph M. Bennett, of Philadelphia; Dr. Spencer, of Chicago; D. C. Rogers, of Detroit; Henry C. Allen, of New York; Mr. Ware, of Boston.

The upshot of the matter will in all probability be a grand chess congress and tournament for the fall to select our strongest player to represent us at the forthcoming Paris Exhibition. Further particulars, as well as the proposed programme, will be given as soon as the committee have prepared their report.

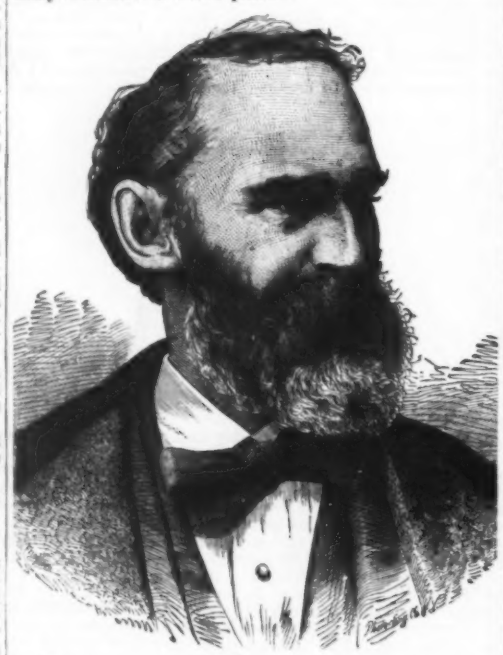
Of course there will be another grand Problem Tournament, and we trust that the programme will be arranged so as to insure a more equal division of the spoils. It is hardly fair that one competitor should take so many prizes, even if *we* own the lucky fellow.

DR. C. C. MOORE.

WE introduce to our readers a most life-like portrait of Dr. C. C. Moore, Secretary of the late Centennial Problem Tournament, and Treasurer of the newly organized "American Chess and Problem Association."

The doctor is well known as a player and problemist, and has taken part in many tournaments throughout the country. He has gained many warm friends by his liberality and genuine enthusiasm for the cause of chess.

His preference is for neat and pretty problems in few moves, fair specimens of which are given this week. He is also well known in the world of invention, and has received many valuable and useful patents.



Yours Truly
S. C. Moore

GRAND INTERNATIONAL CHESS MATCH.

A grand international match by correspondence has been arranged between England and the United States—the following being the names of the players:

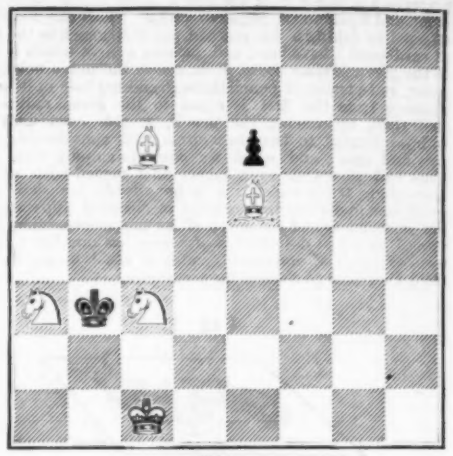
British Team.		*American Team.*
J. Allen	vs.	P. J. Toepfer.
H. Brewer	vs.	Eugene Delmar.
William Coates	vs.	Max Judd.
J. T. C. Chatto	vs.	T. E. Brenzinger.
J. Copping	vs.	Daniel Jager.
J. Crake	vs.	Thomas H. Foster.
G. W. Farrow	vs.	C. G. Lincoln.
G. H. D. Gossip	vs.	Mrs. J. W. Gilbert.
John H. Hood	vs.	C. H. Blood.
E. H. Heath	vs.	Don C. Rogers.
D. M. Latta	vs.	F. H Curtis.
H. W. Molson	vs.	James Burke.
Ser. Maj. McArthur	vs.	A. W. Gentil.
H. Monck	vs.	Jacob Frech.
Wm. T. Morton	vs.	Max H. Peller.
Wm. Nash	vs.	John C. Romeyn.
Jos. O'Brien	vs.	E. A. Kunkel.
J. Parker	vs.	I. E. Orchard.
J. T. Palmer	vs.	F. A. Boothby.
Edwin Palmer	vs.	Edward Hime.
R. H. Phillip	vs.	Rev. L. W. Davis.
Rev. C. E. Ranken	vs.	Wm. J. Berry.
R. J. Stranger	vs.	T. P. Bull.
G. W. Stevens	vs.	H. Holmes.
Col. Sergt. J. Scott	vs.	H. C. Lunt.
Henry Waight	vs.	Leroy S. Atkinson.
H. Williams	vs.	William Olcott
Col. Sergt. Woods	vs.	L. T. Brown.

CHESS.

THE name is said to be derived from the Persian word *shah*, king. As a diversion, it is the most scientific, if not the oldest, having originated in India about five thousand years ago.

PROBLEM No. 2.—BY DR. C. C. MOORE.

Black.



White.

White to play and mate in four moves.

THE RUY LOPEZ GAMBIT.

WHITE.	BLACK.
J. H. Blackburne.	J. H. Zukertort.
1. P to K 4	P to K 4
2. Kt to K B 3	Kt to Q B 3
3. B to Kt 5	P to Q R 3
4. B to R 4	Kt to B 3
5. Kt to B 3 (*a*)	B to B 4 (*b*)
6. Kt takes P	Kt takes Kt
7. P to Q 4	P to Q 3 (*c*)
8. P takes Kt	B takes P
9. Kt to K 2	P to B 3
10. P to K B 4	B to B 2
11. Q to Q 3 (*d*)	P to Q 4
12. P to K 5 (*e*)	Kt to K 5
13. B to K 3	B to B 4 (*f*)
14. Q to Q 4	Castles (*g*)
15. P to B 3	P to K B 3 (*h*)
16. B to Kt 3 (*i*) [1st hour]	Q to K 2 (*j*)
17. P takes P (*k*)	Kt takes K B P
18. Kt to Kt 3	Kt to Kt 5
19. K to Q 2	Kt takes B
20. Q R to K sq (*l*)	Q to R 5
21. R takes Kt	R takes P
22. Kt takes B	R takes Kt
23. K to Q 3	P to B 4 (*m*)
24. Q to K 4 (*n*)	P to B 5, ch
25. B takes P	P takes B, ch
26. K to B 2 (*o*)	Q to B 7, ch
27. R to K 2	Q to B 4 [1st hour]
28. Q takes Kt P	R to Kt sq
29. Q to Q 7 (*p*)	Q to Kt 3 (*q*)
30. K to Kt sq [2d hour]	R to B 2
31. Q to Q 5	Q to Kt 4
32. Q to K 6	Q to K B 4, ch
33. Q takes Q	R takes Q
34. R to K 4	B to Kt 4 (*r*)
35. R takes P	R to B 7
36. P to Q Kt 3	R takes K Kt P
37. P to K R 4	B to B 3
38. R to B 6	R to Q sq (*s*)
39. R takes P	B takes B P
40. R to K B sq	B to B 3
41. P to R 5	R to Kt 7 ch
42. K to R sq	R to K B 7, dis ch
Resigns.	

(*a*) This move was, we believe, first introduced by Paulsen in his famous games played against Morphy in the New York tournament of 1857.

(*b*) The usual reply is P to Q 3, but Black adopts this apparently dangerous defence on the strength of the new manœuvre by which it is followed.

(*c*) A fine move; for he prepares a sound attack without the least risk, as Black cannot capture the P on account of the reply Q to Q 5.

(*d*) Feeble in the extreme; for it may be regarded as tantamount to throwing away the advantage of the first move. It was manifestly stronger play to advance the P to K 5 at once, *e. g.*:

WHITE.	BLACK.
11. P to K 5	Kt to K 5
12. Q to Q 4	P to K B 4
13. B to K 3	Castles.
14. B to Kt 3, ch	K to R sq
15. Kt to Kt 3 followed by castling on the Q side, with the superior game.	

(*e*) Strong as it would have been before the advance is quite unsuitable now, for the P at K 5 is soon made an object of attack after the opponent's castling. The best plan would have been now to capture the P, and to endeavor to keep the game even by exchanging queens.

(*f*) Better than B takes P; for, though the latter gained a P, it would have equalized the game, the parties remaining with bishops of opposite colors, *e. g.*:

WHITE.	BLACK.
13.	B takes K P
14. P takes B	Q to Q R 4, ch
15. Kt to B 3	Kt takes Kt
16. B takes P, ch	P takes B
17. Q takes Kt, etc.	

(*g*) White on the last move could not attempt to prevent the castling by Q to Q R 3 on account of the reply P to Q Kt 4, driving back the B, followed by P to Q Kt 5, which P obviously could not be captured by the Q without subjecting the latter to loss by B to Q R 4. The Q would then have been compelled to keep confined at Q R 4. Black under the present circumstances had obtained an excellent game, and in our opinion acted wisely in not yielding to the temptation of winning a piece by the following manœuvre:

WHITE.	BLACK.
14.	P to Q Kt
15. B to Kt 3	P to Q B 4
16. Q takes Q P	P to B 5
17. Q to B 6, ch	K to B sq
18. Kt to Q 4	P to Kt 3
19. B takes P, obtaining three pawns for the piece, with an excellent game.	

(*h*) Since Mr. Steinitz introduced this move in a similar position in the Ginoco Piano, the force of thus breaking the pawns has been recognized in almost all cases where the adverse pawn has been advanced to K 5.

(*i*) White's position was already inferior; but certainly the best recourse would have been to give up the P at once by advancing P to K 6, in order not to give the opponent two open files for the rooks.

(*j*) Nor was this best, for it still leaves White the chance of diminishing his disadvantage by giving up the P at once as above; while taking the P first, followed by Q to K 2, would have secured the gain of the P, and also free action for both rooks.

(*k*) From this point White's game might be reckoned as lost, for Black's attack is irresistible.

(*l*) This loses the exchange at last; but he had hardly anything better. Had he taken the Kt at once, Black would have obtained a winning position in a simple manner, which left hardly any room for an error on the part of the opponent on account of complications, *e. g.*:

WHITE.	BLACK.
20. Q takes Kt	Q takes Q, ch
21. K takes Q	R to K sq, ch
22. K to B 3	B to Q 6, etc.

(*m*) Very fine play.

(*n*) The best under the circumstances (bad as it was anyhow) was to capture the Q B P with the Q, and to try to escape with the exchange behind. B takes P, ch. was of no more use, *e. g.*:

WHITE.	BLACK.
24. B takes P, ch	K to R sq
25. Q to K 4	R takes B, ch
26. Q takes R	B to Q sq
27. R to K 8, ch	R takes R, with a piece ahead.

(*o*) Had he taken the B P, checking, Black would have moved the K into the corner, threatening Q to Q sq, ch, winning speedily.

(*p*) Taking the R P would have been immediately disastrous, on account of the reply R to K B 3, attacking the Q, at the same time clearing the way for the terrible ch of Black's Q at K B 4, with the subsequent mate at Q K 8.

(*q*) Mr. Minchin, the hon. sec. of the St. George's Chess Club—who, with some other strong players analyzed the game in another room of the establishment—pointed out that Black would have won the game much quicker here by the following fine mode of procedure:

WHITE.	BLACK.
29.	B to K 4
30. R to Q B 2, or Q to K Kt 4 (K R to K sq would be fatal at once, for Black would exchange rooks, followed by Q to Kt 8, ch, etc.).	R to Q Kt 4, and wins.

(*r*) If White was in hopes of his opponent committing a mistake, here was the last chance. But Black cautiously avoids B to K 4, which would have cost a piece, owing to the reply P to K Kt 4, followed by P to K R 4.

(*s*) As this enables Black ultimately to bring both rooks on the 7th file, White might just as well have resigned here.